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Estimates of fish-, spill-, and sluiceway-passage efficiencies of radio-tagged juvenile Chinook salmon during spring and summer at The Dalles Dam in 2004

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Final Report of Research

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Executive Summary

- During spring (27 April through 28 May) and summer (19 June through 28 July) 2004, 2230 radio-tagged yearling Chinook salmon of hatchery origin and 2210 subyearling Chinook salmon of unknown origin were released in the John Day Dam tailrace. These fish were monitored at The Dalles Dam (TDA) to 1) determine the horizontal distribution of fish at up- and downriver entrances to the forebay and the effect of horizontal approach location on turbine entrainment; 2) determine the effect of two sluiceway operation scenarios; 3) estimate total project fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE), and; 4) determine the distribution of passage at spill bays 1 through 6 relative to the new spillway training wall.

- Guiding juvenile migrants entering the forebay away from the powerhouse could potentially increase FPE. The probability of being entrained in the turbines was greatest for those radio-tagged yearling or subyearling Chinook salmon whose point of entry into the forebay was closest to the powerhouse and at night. This was measured by estimating passage routes of fish detected at one of four horizontal areas along cross-river transects at the upstream end of the earthen dam (upriver entrance) and at main unit 22 (downriver entrance; Summary Tables 1 and 2). During the day, yearling Chinook salmon FPE was 3% lower for fish approaching the forebay from the south near the powerhouse than for fish approaching by more northerly routes at the downriver entrance. At night, FPE was 27% lower for fish approaching from the south than the north. Subyearling Chinook salmon FPE relative to their north and south horizontal locations at the downriver forebay entrance differed by 7% during the day and by 42% at night. Overall, about 28% of yearling Chinook salmon and 43% of subyearling Chinook salmon at the downriver entrance approached the forebay at the southernmost area.

- Operating a sluiceway entrance at the east and west ends of the powerhouse instead of operating only one entrance at the west end, as in past years, did not notably improve SLPE or FPE (Summary Table 3). Only 3% of the radio-tagged yearling Chinook salmon and 12% of the subyearling Chinook salmon that passed via the sluiceway entered through the east entrance (MU18) when both the east and west (MU01) entrances were operating. Our results indicate that MU18 was not an optimal location for the east entrance and that greater benefits may be obtained if the east entrance was located about half the distance between where the westernmost and easternmost powerhouse loading occurs.

- Estimates of total project FPE, SPE, and SLPE for all radio-tagged yearling and subyearling Chinook salmon detected in the forebay were significantly greater during the day than at night (Summary Table 4). At night, 15% more of the yearling Chinook salmon and 29% more of the subyearling Chinook salmon passed via the turbines than during the day. Yearling Chinook salmon total project

FPE, SPE, and SLPE estimates were 93, 84, and 9%, respectively. Subyearling Chinook salmon FPE, SPE and SLPE estimates were 85, 78, and 7%. Yearling Chinook salmon spill effectiveness was 2.3 during the day, 1.7 at night, and 2.2 overall. Subyearling Chinook salmon spill effectiveness was 2.2 during the day, 1.5 at night, and 2.0 overall.

- Although almost all spill discharge was equally distributed among the 6 spill bays north of the spill training wall, most fish passed at bays 6 and 5 closest to the wall. About 23% of the spring and summer fish passed through bay 6 and 6 to 7% passed through bay 1.

Summary Table 1. Diel fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) estimates (Est) of yearling Chinook salmon detected at the upriver and downriver entrances by approach location during 40% bulk spill discharge at The Dalles Dam, 28 April through 29 May 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. *N* = sample size adjusted for detection efficiencies. The north shore location was not included for all conditions due to small sample sizes (Figures 16 and 19). CI = 95% confidence interval. Day and Night confidence intervals are either profile- (^{B}) or quasi-likelihood (^{Q}) estimates. An asterisk (*) indicates a significant difference among approach locations during the day or night periods at the α = 0.05 level.

		Upriver Entrance					
		Day			Night		
Passage efficiency	Approach location	Est %	95% CI	*N*	Est %	95% CI	*N*
$FPE^{Q,B*}$	BN	98.0	96.3 - 99.0	742	86.6	82.5 - 90.0	317
	BS	96.0	89.6 - 99.0	124	67.7	50.3 - 82.3	31
	SS	97.7	90.7 - 99.8	86	72.0	52.8 - 86.9	25
$SPE^{B,B*}$	BN	90.3	88.0 - 92.3	742	69.7	64.5 - 74.5	317
	BS	87.1	80.5 - 92.2	124	45.2	28.5 - 62.5	31
	SS	90.7	83.4 - 95.6	86	52.0	32.9 - 70.7	25
$SLPE^{B,Q}$	BN	7.7	5.9 - 9.7	742	16.9	11.5 - 23.3	317
	BS	8.9	4.7 - 14.7	124	22.6	6.8 - 47.0	31
	SS	7.0	2.8 - 13.6	86	20.0	4.4 - 47.0	25
		Downriver Entrance					
$FPE^{B*,B*}$	NS	100.0	100.0 - 100.0	55	100.0	100.0 - 100.0	36
	BN	100.0	100.0 - 100.0	505	96.5	92.5 - 98.1	194
	BS	99.4	97.5 - 100.0	174	92.1	80.8 - 98.0	38
	SS	96.7	94.2 - 98.4	276	73.0	64.8 - 80.2	123
$SPE^{Q*,B*}$	NS	96.4	88.0 - 99.5	55	97.2	88.3 - 99.8	36
	BN	97.2	95.3 - 98.6	505	88.1	83.1 - 92.2	194
	BS	94.2	89.5 - 97.3	174	78.9	64.4 - 89.8	38
	SS	79.0	73.3 - 84.0	276	40.5	32.2 - 49.2	123
$SLPE^{Q*,B*}$	NS	3.6	0.3 - 13.2	55	2.8	0.2 - 11.7	36
	BN	2.8	1.4 - 4.9	505	7.7	4.5 - 12.0	194
	BS	5.2	2.1 - 10.3	174	13.2	4.9 - 26.2	38
	SS	17.8	12.6 - 23.8	276	32.5	24.8 - 41.0	123

Summary Table 2. Diel fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) estimates (Est) of subyearling Chinook salmon detected at the upriver and downriver entrance by approach location during 40% bulk spill discharge at The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. *N* = sample sizes adjusted for detection efficiencies. The north shore location was not included for all conditions due to small sample sizes (Figures 39 and 42). CI = 95% confidence interval. Day and Night confidence intervals are either profile- (^{B}) or quasi-likelihood (^{Q}) estimates. An asterisk (*) indicates a significant difference among approach locations during the day or night periods at the $\alpha = 0.05$ level.

Passage efficiency	Approach location	Upriver Entrance					
		Day			Night		
		Est %	95% CI	*N*	Est %	95% CI	*N*
$FPE^{Q,Q}$	BN	95.2	92.6 - 97.1	537	73.3	65.0 - 80.6	198
	BS	91.2	84.7 - 95.6	159	69.8	59.0 - 79.4	126
	SS	90.0	81.2 - 95.7	100	45.8	30.1 - 62.0	56
$SPE^{Q,Q}$	BN	87.3	82.6 - 91.2	537	67.8	59.2 - 75.7	198
	BS	83.0	72.9 - 90.7	159	61.9	50.7 - 72.3	123
	SS	79.0	65.3 - 89.3	100	37.3	22.7 - 53.7	56
$SLPE^{Q,B}$	BN	7.8	3.4 - 14.7	537	5.4	2.9 - 9.2	198
	BS	8.2	1.5 - 22.6	159	7.9	4.1 - 13.5	123
	SS	11.0	1.7 - 31.5	100	8.5	3.1 - 17.3	56
		Downriver Entrance					
$FPE^{B*,B*}$	NS	94.7	84.6 - 99.1	38		-	
	BN	99.4	98.2 - 99.9	336	95.8	92.1 - 98.2	167
	BS	97.7	93.2 - 99.6	89		-	
	SS	92.3	89.1 - 94.9	326	53.7	46.6 - 60.8	188
$SPE^{Q*,Q*}$	NS	92.1	68.5 - 99.6	38		-	
	BN	94.0	88.4 – 97.6	336	90.4	82.4 - 95.7	167
	BS	86.5	70.8 – 95.8	89		-	
	SS	80.4	71.9 - 87.3	326	43.6	33.3 - 54.3	188
$SLPE^{Q*,Q*}$	NS	2.6	0.0 - 23.8	38		-	
	BN	5.4	2.0 - 11.1	336	5.4	1.2 - 14.4	167
	BS	11.2	2.8 - 27.2	89		-	
	SS	12.0	6.4 - 19.6	326	10.1	3.9 - 20.2	188

Summary Table 3. Yearling (CH1) and subyearling (CH0) Chinook salmon sluiceway (SLPE) and fish (FPE) passage efficiency point estimates (Est) during two sluiceway operation scenarios at The Dalles Dam, spring and summer 2004. MU01 = main turbine unit (MU) 01 entrance open. MU01+MU18 = MU01 and MU18 entrances open. 95% CI = 95% confidence interval. Confidence intervals are either profile- (^{B}) or quasi-likelihood (^{Q}) estimates. *N* = sample size adjusted for detection efficiencies.

Migrant	Passage efficiency	MU01 Treatment Est %	MU01 Treatment 95% CI	MU01 Treatment *N*	MU01+MU18 Treatment Est %	MU01+MU18 Treatment 95% CI	MU01+MU18 Treatment *N*
CH1	SLPE^B	9.6	7.8 - 11.6	953	7.4	5.9 - 9.1	1011
	FPE^Q	92.5	89.7 - 94.7	953	92.9	90.3 - 95.0	1011
CH0	SLPE^Q	4.4	2.5 - 7.0	569	3.6	1.9 - 6.2	521
	FPE^Q	84.9	80.4 - 88.7	569	86.4	81.9 - 90.2	521

Summary Table 4. Diel and overall fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) estimates of yearling Chinook salmon detected at The Dalles Dam during 40% bulk spill discharge, 28 April through 29 May 2004. QRCI = quasi-likelihood ratio confidence interval. *N* = sample size adjusted for detection efficiencies. An asterisk (*) indicates a significant difference between day and night estimates at the $\alpha = 0.05$ level.

Migrant	Diel Period	Passage efficiency	Estimate %	95% QRCI	*N*
CH1	Day	FPE*	97.1	96.0 - 98.0	1514
		SPE*	90.7	88.8 - 92.3	1514
		SLPE*	6.4	5.0 - 8.0	1514
	Night	FPE	81.9	78.0 - 85.5	587
		SPE	67.5	62.8 - 71.9	587
		SLPE	14.5	11.3 - 18.1	587
	Overall	FPE	92.9	90.6 - 94.8	2101
		SPE	84.2	81.0 - 87.1	2101
		SLPE	8.7	7.1 - 10.4	2101
CH0	Day	FPE*	93.1	91.2 - 94.8	1302
		SPE*	86.3	83.6 - 88.8	1302
		SLPE	6.8	5.1 - 8.8	1302
	Night	FPE	64.5	59.2 - 69.6	543
		SPE	58.1	52.2 - 63.8	543
		SLPE	6.5	4.0 - 9.6	543
	Overall	FPE	84.5	80.8 - 87.8	1845
		SPE	77.9	73.9 - 81.5	1845
		SLPE	6.7	5.2 - 8.3	1845

Introduction

Turbine passage at The Dalles Dam (TDA) remains a cause of concern and regional managers have been exploring surface bypass strategies to reduce juvenile salmonid turbine passage and enhance fish survival. Turbine units at TDA are not screened as they are at other lower Columbia River dams to divert out-migrating juvenile salmonids (*Oncorhynchus* spp.*)* from the turbine intakes. In part, this is due to the relatively high passage efficiency of smolts through the spillway and the sluiceway. Depending on the percentage of total river flow spilled at the project, they together typically pass 80 to 90% of the juvenile salmonids (Ploskey et al. 2001). Even so, the relative survival of the remaining 10 to 20% of the Chinook salmon that pass via the turbines is 82 to 85%, compared to survival rates of 88 to 91% for the spillway and 91% for the sluiceway (Counihan et al. 2003).

From 2001 through 2003 the U. S. Army Corps of Engineers (USACE) initiated numerous studies at TDA with objectives addressing various surface bypass strategies. In 2001 and 2002, the USACE contracted the U.S. Geological Survey (USGS) concurrently with the Batelle Memorial Institute to determine the effect of sluiceway guidance improvement devices (SGID) on turbine entrainment at TDA (Beeman et al. 2004, Hausmann et al. 2004, Johnson et al. 2003). In 2003 and 2004, the USACE again contracted the USGS, to conduct new studies at TDA relevant to the potential use of other surface bypass devices such as a forebay guidance curtain and removable surface weir employed on the lower Snake River at Lower Granite Dam (Adams and Rondorf 2001, Plumb et al. 2004). In 2003, the USGS's specific objectives were to: 1) estimate the horizontal distribution of radio-tagged yearling and subyearling Chinook salmon (*O. tshawytscha*) entering the TDA forebay, 2) estimate the proportion of radio-tagged fish passing TDA via the spillway, turbines, and sluiceway relative to their horizontal forebay entrance location and for the project as a whole, and 3) obtain information on the behavior of radio-tagged fish in the near-dam area prior to passage (Hansel et al. 2004).

In 2004, this work was repeated with the addition of two new objectives related to the current surface bypass strategies: 4) to estimate sluiceway passage efficiency during two sluiceway operation scenarios and 5) to estimate spill bay passage relative to the new spillway training wall. The need for the first additional objective arose from a finding by the USACE in 2003 that another sluiceway entrance (3 sluice gates) could be opened above a second turbine in addition to the entrance (3 sluice gates) currently in use without exceeding the hydraulic capacity of the sluiceway. The last objective arose from completion of a spill training wall dividing the stilling basin between bays 6 and 7 and the initiation of a bulk spill pattern at bays 1 through 6 in an attempt to improve survival of fish through the spillway. Therefore, the 2004 radio-telemetry study at TDA continued the sequence of studies to access out-migrant fish behavior relative to existing and proposed engineering designs and dam operations intended to increase juvenile salmonid passage survival.

Methods

Study Site

The Dalles Dam is located on the Columbia River at river km 307 (Figure 1). The dam consists of a single powerhouse of 22 MUs, 2 fish units (FU), and a spillway of 23 tainter gates. The powerhouse is oriented parallel to river flow and the spillway is perpendicular to river flow. The sluiceway runs the length of the forebay side of the powerhouse from east to west and empties into the tailrace below MU01. A non-overflow wall connects the powerhouse and spillway, and a navigation lock is located at the northwest end of the dam. The natural thalweg turns abruptly southeast near the east end of the powerhouse, continues along the powerhouse tailrace, and passes under the highway 197 bridge near the Washington shore.

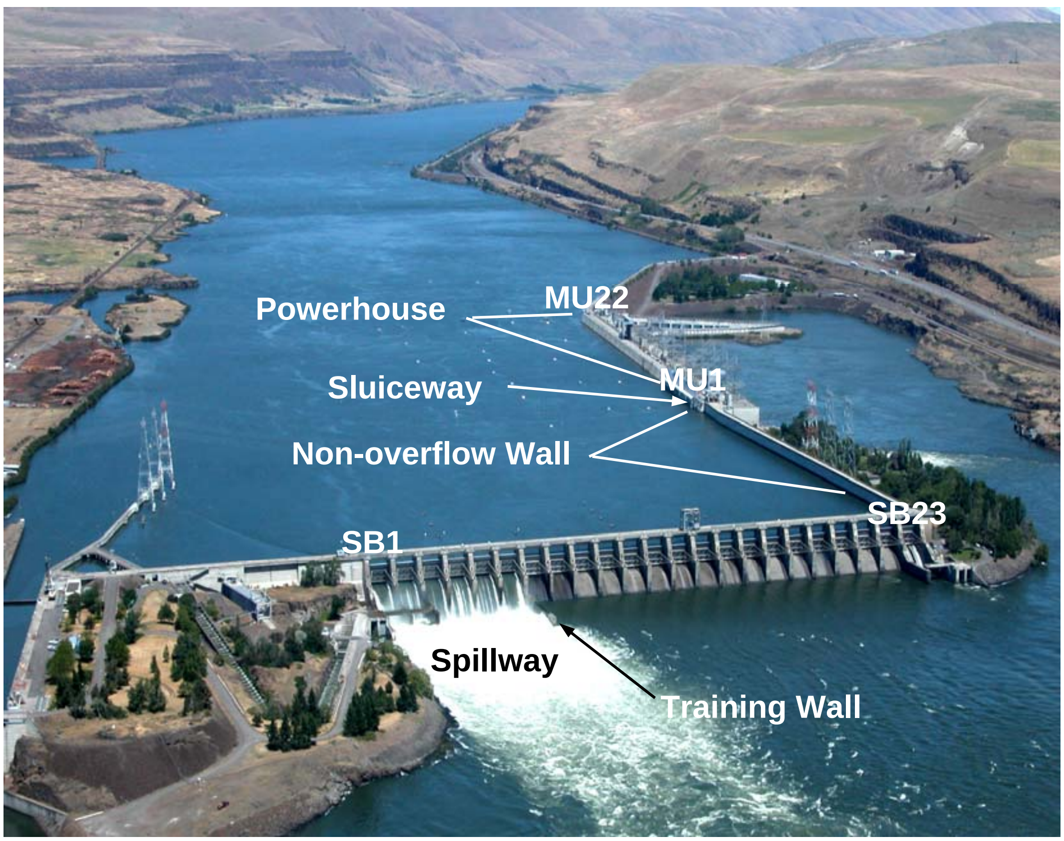


Figure 1. The Dalles Dam (river km 307) study site on the Columbia River. SB = spill bays numbered from north to south. MU = main turbine units numbered from west to east.

Study Design and Dam Operations

The study was divided into spring (28 April through 29 May; yearling Chinook salmon migration) and summer (19 June through 29 July; subyearling Chinook salmon migration) periods. The summer portion of the study was extended an additional two weeks longer in length than the spring study at the request of the Bonneville Power Administration and USACE to examine the feasibility of conducting fish collection, tagging, holding, and release activities during the higher water temperatures typically seen in late-July. The sluiceway operations test consisted of a randomized 2-day block design with two alternating 1-d treatments through 17 July (Appendix A). The MU01 treatment consisted of opening the MU01entrance at the west end of the powerhouse, whereas the MU01+MU18 treatment consisted of opening the MU01 entrance and a second sluiceway entrance at MU18 on the east end of the powerhouse. Each sluiceway entrance was made up of three 20-ft wide sluice gates located above the corresponding turbine unit. Treatments were changed in about a 15 min period starting at 0800 hours.

The total flow and average water velocities over the weirs into the MU01 and MU18 entrances at a particular forebay elevation is dependent on the treatment and entrance location (Johnson et al. 2005a). For example, during the MU01 treatment at a forebay elevation of 158.4 ft (about the spring and summer average) the total flow into the MU01 entrance is 3138 cubic feet per second (cfs), whereas during the MU01+MU18 treatment, 2655 cfs enter the MU01 entrance and 1795 cfs enter the MU18 entrance for a total of 4451 cfs which is closer to the hydraulic capacity of the sluiceway channel (about 4600 cfs). Opening two sluiceway entrances reduces the average water velocity from 7 ft/s when only one entrance is open to 6 ft/s at the MU01 entrance; the average water velocity at the MU18 entrance when open is 4 ft/s.

During spring and summer, spill operations generally consisted of 40% continuous bulk spill discharge equally distributed among spill bays 1 through 6 (bulk discharge pattern) on the north side of the new training wall, with small amounts of spill occurring south of the wall as necessary during higher river flows. The training wall was designed to direct spill discharge and fish away from shallow-water areas adjacent to rocks and islands on the south side of the tailrace known to contain predators, including the northern pikeminnow (*Ptychocheilus oregonesnsis*; Shively et al. 1996, Martinelli et al. 1997, Duran et al. 2004). Hourly powerhouse and spillway discharge data were obtained from the USACE (2004) and compiled by the USGS for each study period.

Fish Tagging, Handling, and Release

This study used radio-tagged yearling Chinook salmon of hatchery origin and subyearling Chinook salmon of unknown origin. Fish to be implanted with radio transmitters were obtained through the Smolt Monitoring Program at John Day Dam and were typically held at the collection facility for 12 to 24 h prior to tagging. Fish free of major injuries, severe descaling, external signs of gas bubble trauma, or other obvious abnormalities were gastrically implanted using the methods of Martinelli et al. (1998). The minimum size of yearling and subyearling Chinook salmon tagged was 21.5 and 13.0 g, corresponding to a tag weight (in air) to body weight ratio for both groups of 6.5%.

Individual fish were recognized by pulse-coded transmitters operating at 7 different frequencies during spring and 10 different frequencies during summer between 150.280 and 150.740 MHz. Individual frequencies were at least 20 MHz apart from the other frequencies used. Two sizes of transmitters were used to accommodate the different sizes of the spring and summer migrants. Transmitters implanted in yearling Chinook salmon were 7.3 mm in diameter x 18.0 mm in length and weighed 1.4 g in air and 0.80 g in water (model MCFT-3KM; Lotek Wireless, Newmarket, Ontario, Canada[1]). Transmitters implanted in subyearling Chinook salmon were 6.3 mm x 4.5 mm x 14.5 mm long and weighed 0.85 g in air and 0.50 g in water (Lotek Wireless model NTC-3-1). Both transmitter types had a 30-cm whip antenna. Based on tag-life studies conducted by Counihan et al. (2006b), the average tag life of the spring tag was 10 days (range 7-12 days) and the average tag life of the summer tag was 9 days (range 7-12 days).

Fish were held in tanks at the collection facility for 20 to 28 h after tag implantation to allow fish time to recover from the procedure. At the end of the recovery period, the holding tanks were checked for mortalities before the fish were transported and released by boat into the John Day Dam tailrace. When present, regurgitated tags were removed from the holding containers immediately prior to release. Releases were made daily at 0700 and 1900 hours during spring and 0600 and 1800 hours during summer.

[1]Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Telemetry Receiving Equipment

Radio-tagged fish were detected near TDA with four-element Yagi (aerial) and underwater antennas (standard dipole antennas as described by Beeman et al. 2004). Aerial antennas mounted on two mid-channel barges, in conjunction with aerial antennas on the north and south shorelines were used to determine the horizontal distribution of radio-tagged migrants entering the forebay (Figure 2). The first entrance point, located furthest upriver (upriver entrance), was at the eastern end of the earthen dam on the south shore of the project and the second entrance was located between MU21 and MU22 on the east end of the powerhouse (downriver entrance).

On the dam, aerial antennas were positioned along the forebay side of the powerhouse and spillway to detect fish within about 100 m of the dam face, hereafter referred to as the near-dam area. Individual aerial antennas were spaced such that a pair

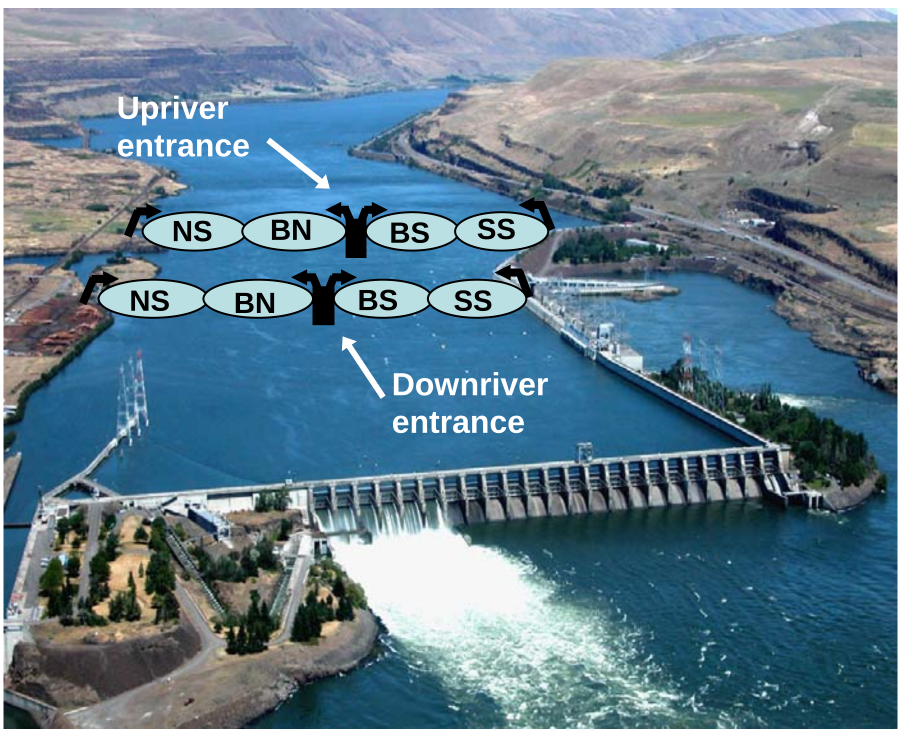


Figure 2. Upriver and downriver entrance locations at The Dalles Dam used to determine radio-tagged yearling and subyearling Chinook salmon horizontal location as they approached the forebay upriver of the dam during 2004. The black rectangles represent mid-channel barges with antennas (black arrows) facing to the north and south. Additional entrance array antennas were located on the north and south shorelines. General areas of fish location: NS = north shore, BN = Barge north, BS = barge south, SS = south shore. United States Army Corps of Engineers Photo (not representative of spill conditions during study).

of combined antennas monitored an area in front of four turbine units or three spill bays. Seven aerial antennas were used to monitor the entrance at MU01 and outfall of the sluiceway and eight aerial antennas were evenly spaced along the forebay side of the non-overflow wall. Aerial antennas at the powerhouse were aimed almost vertically downward toward the water surface to reduce their range of detection to a maximum of 80 m from the dam, restricting data collection to those fish nearest the powerhouse. Additional aerial antennas were used to monitor the tailrace. All Yagi antennas, except those monitoring the sluiceway, were connected to SRX-400 receivers (Lotek Wireless, Newmarket, Ontario, Canada), which recorded the telemetry data, following the methods of Hensleigh et al. (1999). Each SRX-400 receiver was configured to scan all attached antennas combined (the master antenna), until it received a signal and then cycle through individual aerial antennas (auxiliary antennas) to determine a more accurate location of the transmitter.

Underwater dipole antennas in the forebay were used to monitor radio-tagged juvenile salmonids within about 10 m of each turbine unit or pair of spillway tainter gates (Beeman et al. 2004). Underwater dipole antennas were mounted at several elevations to the main pier noses between all MUs, MU01 and FU01, and the pier nose to the west (downstream) of FU02. The antennas were mounted at elevations 140, 120 and 100 ft above mean sea level (MSL), which correspond to water depths of 20, 40, and 60 ft below the normal operating pool elevation of 160 ft above MSL (Figure 3). Fish entering the

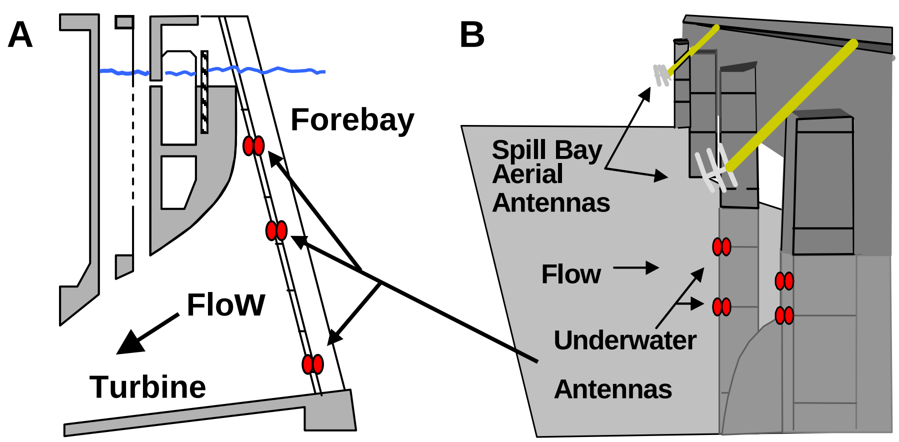


Figure 3. Location of underwater antennas on pier noses between turbine units 1 through 22 (A), and the location of aerial and underwater antennas on spill bay pier noses (B) at The Dalles Dam, 2004. Each aerial antenna detected fish in front of two spill bays.

sluiceway via the east sluice gates at MU18 were detected using underwater antennas in the sluiceway channel at MU12 and MU13. The inputs from all the underwater antennas and the aerial antennas in the sluiceway were monitored using a Multiprotocol Integrated Telemetry Acquisition System (MITAS; Grant Systems Engineering, King City, Ontario, Canada), which is a PC-based telemetry data collection system.

Data Management and Analysis

Data from radio-telemetry receivers and the MITAS system were typically downloaded every day and then proofed and analyzed using SAS software (Version 8.2, SAS System for Windows, copyright © 1999-2001 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA). These data were merged with release information for each radio-tagged fish and electronically proofed using a program created in SAS to filter out background noise. Potential individual fish data records were designated as noise if: composed of invalid channel and code combinations; logged before a fish's release; below an empirically determined signal strength threshold for each aerial and underwater array; there were fewer than two records within a 20-min period, or; less than 5 records in a 60-min interval on the MITAS underwater antenna array or a single aerial receiver unsupported by at least one record on the corresponding forebay aerial or underwater array during the same hour, or a minimum of two other records at the entrance, sluiceway, tailrace, and exit station over a 3-h period beginning 1 h before and ending 1 h after the 60-min interval.

First entrance times, first and last forebay locations and times, first underwater antenna location and time, first and last tailrace locations and times, and first and last exit station times were assigned after the data sets were filtered for background noise. Due to overlapping areas of detection among underwater and aerial antenna arrays and different amounts of resolution in location between antenna types, the antenna type and signal strength were used to assign first and last locations in the forebay. During the first 90 s of forebay detection, a fish's time and area of first location was assigned based on the first underwater antenna detection when present. In the event of simultaneous detections on two adjacent underwater antennas, fish were assigned to a single location corresponding to the antenna with the highest signal strength. Fish not detected on underwater antennas during the first 90 s, were assigned first forebay times and locations based on the auxiliary antenna record having the highest signal strength during that interval, or the master antenna record with the strongest signal strength if there were no auxiliary antenna records. Similarly, a fish's last forebay location and time was assigned based on antenna type and signal strength during the last 90 s of a fish's detection history. In order of preference, last location and time was determined based on the last underwater detection, auxiliary aerial antenna with the strongest signal strength, or master antenna record with the highest signal strength during the last 90 s of a fish's forebay records. A 90-s interval was chosen in assigning first and last forebay locations because it approximately coincided with the upper boundary of time needed to complete a receiver scan cycle if several fish were present at any given time.

At both forebay entrance transects, fish were assigned general horizontal locations in the north (north shore and barge north) and south (barge south and south shore) portions of the river. Fish detected by antennas at more than one location at an entrance were assigned to the single location having the highest signal strength during the last 90 s of detection at the entrance. The time a radio-tagged fish was first detected by forebay antennas was considered the time of arrival at TDA and a fish's approach to the dam was defined as the location of first detection within 10 m of the dam (near-dam area) on the underwater antenna array. The location and time of the last detection of an individual fish on the telemetry equipment on the dam face was considered the route and time of passage through the dam. Fish last detected in the sluiceway were considered to have passed at the powerhouse, but via the non-turbine sluiceway route.

Upriver and downriver entrance (Figure 2) residence times and forebay residence times were determined. Upriver and downriver entrance residence time, metrics not used in past studies, were defined as the time between a fish's first detection at the upriver entrance (upriver residence time) or downriver entrance (downriver entrance time) and the last detection in the forebay within approximately 100 m of the dam. Forebay residence time, as in the past, was defined as the amount of time between the first detection within about 100 m of the dam and the last forebay detection. Thus, as calculated, upriver entrance residence time included the time defined by downriver and forebay residence time and downriver entrance residence time included the time defined by forebay residence time. These residence times are minimum estimates of the actual time that radio-tagged fish spent in the near-dam area due to the chance that a fish might have been in the near-dam area for an unknown amount of time prior to their first detection and following their last detection. Residence times in the tailrace and at the exit station were calculated similar to forebay residence time.

Once all times and locations of interest (events) were electronically assigned, individual fish histories were verified using criteria based on empirical data from previous years of radio-telemetry data for the same species. A fish's event history was considered potentially suspect if 1) the probability of an observed travel time between release and first forebay, tailrace, or exit detection was less than 0.01 based on a model developed from relations between fish travel rates and total dam discharge (Zabel and Anderson 1997), 2) forebay, sluiceway, tailrace, and exit residence times exceeded the 95th percentile of similar 2002 and 2003 metrics, or 3) a fish's events were chronologically out of order. Fish whose event histories were suspect because of one or more of the above criteria were manually proofed and reconciled with the electronic proof prior to further analyses. The program output was validated against manually proofed releases during the early portion of the study and at least 10% of all fish with non-suspect fish histories were randomly sampled from each release throughout the study and then manually proofed for quality assurance.

Before calculating the proportion of fish passing TDA by each route, diel fish detection probabilities at the turbines, spillway, and sluiceway were determined and used to adjust the observed number of fish passing TDA via each passage route daily. The detection efficiencies of the telemetry arrays at the powerhouse, spillway, and sluiceway were calculated using a "double array" system as described by Lowther and Skalski (1997). This method is based on the number of fish detected and undetected at each of two arrays to determine the detection probability of each array, and ultimately, the combination of the two arrays. In a double-array system, the detection probability of one array is estimated as:

$$P1 = 11/(11+01) \qquad \text{Equation 1}$$

where 11 denotes the number of fish that were detected on both arrays and 01 denotes the number of fish not detected on the first array, but detected on the second. The detection probability of the second array is estimated as:

$$P2 = 11/(11+10) \qquad \text{Equation 2}$$

where 10 denotes the number of fish detected on the first array, but not the second. Fish that are detected at array 1 have the same detection probability at array 2 as fish that are not detected at array 1. This allows the fish detected at array 1 to be used to estimate the detection probability for array 1. The overall detection probability of the combined arrays is estimated as:

$$P12 = 1-((1-P1)(1-P2)) \qquad \text{Equation 3.}$$

The forebay aerial and underwater arrays at the powerhouse and spillway were each considered as a single upstream array (P1) for that route of passage and the aerial antennas in the tailrace of each area were considered the downstream arrays (P2). The two arrays in the sluiceway were composed of aerial antennas within the sluiceway between MU01 and the corner before the drop to the tailrace side (P1) and aerial antennas within the sluiceway at the roadway bridge near the sluiceway outfall (P2). The numbers of fish detected passing at the spillway, powerhouse or sluiceway were adjusted by dividing the numbers detected passing at one of these routes by the overall detection probability for that route (P12, equation 3). For example, the adjusted number of fish passing through the powerhouse during a day or night period would be estimated as:

$$PH_{adj} = PH_{obs} \; / \; PH_{dprob} \qquad \text{Equation 4.}$$

Where PH_{adj} and PH_{obs} are the adjusted and unadjusted numbers of fish detected passing the powerhouse, and PH_{dprob} is the detection probability at the powerhouse.

Fish passage efficiency (proportion of all radio-tagged yearling or subyearling Chinook salmon passing TDA that passed via non-turbine routes, multiplied by 100%; FPE) was calculated for each group of fish assigned to a particular horizontal river location at the upriver and downriver entrances. Similarly, spill passage efficiency (SPE) and sluiceway passage efficiency (SLPE) was estimated as the proportion of the total number of radio-tagged yearling or subyearling Chinook salmon passing the dam via the spillway or sluiceway, multiplied by 100%. Differences in FPE, SPE, and SLPE for fish entering the forebay at the four horizontal river locations along each entrance transect were statistically compared within the day and night period using a logistic regression procedure with chi-square tests of odds ratios (Allison 1999, Stokes et al. 2000). This is accomplished during the logistic procedure by linking the expected value of the proportion to the logit function and estimating parameter values by fitting the data via maximum likelihood estimation. The SAS GENMOD procedure was used to fit the logistic regression models. When an overall significant difference in FPE, SPE, or SLPE among groups of fish assigned individual horizontal river locations was indicated, linear combinations of the parameters were tested to see if they were significantly different from zero in order to determine if any of the proportions for the entrance locations were similar. Day and night were defined as the hours from 0530 to 2059 and 2100 to 0529.

Although sluiceway treatments occurred during the entire spring period and most of the summer period, they were not included as model effects when assessing differences in passage metrics among forebay approach locations since there was little evidence of an association between sluiceway operations and route of passage. Contingency table analyses, with the exception of only two cases, revealed no statistically significant associations between sluiceway treatment and passage route after controlling for diel period and each of the horizontal forebay approach locations at the up- and downriver entrances during spring and summer (Pearson chi-square test, asymptotic or exact, all $P >$ 0.08, df = 2). One significant association between sluiceway treatment and passage route was found during spring for fish approaching the upriver entrance at the south barge location at night (chi-square exact test, $P < 0.005$, df = 2) and the other was found during summer for fish approaching the downriver entrance at the south shore during the day (chi-square test, $P < 0.01$, df = 2). In the first case the sample sizes were small for each sluiceway operation (N = 10 and 19) and in the second case, the small differences in the percentages of fish passing each route between sluiceway treatments (< 10%) did not alter the general trend in passage behavior among the four horizontal locations at the downriver entrance regardless of sluiceway operation.

Project SLPE and FPE were calculated for both sluiceway treatments during each block of the sluiceway experiment and compared using the logistic regression methods described above. Fish were assigned to sluiceway treatments, diel periods, and blocks based on the time of passage. Overall project FPE, SPE, and SLPE were calculated and compared between diel periods for the entire spring and summer seasons. Spill effectiveness was calculated as the SPE proportion divided by the proportion of total dam discharge spilled. Seasonal variation in the estimation of passage metrics was assessed and adjusted for during three seasonal periods for upriver approach, by block during the sluiceway test, and on a daily basis for overall project estimates. Three time periods were chosen to assess seasonal variation for upriver approach analyses, rather than more time periods to avoid small sample sizes for locations.

Overdispersion or the lack of model fit due to estimation of the logit model with grouped data was assessed by examining the residual deviance and residual degrees of freedom. Consistency of the data with the null hypothesis of no overdispersion was measured using the chi-square *P*-value for the model's residual deviance and residual degrees of freedom. A *P*-value > 0.25 was considered to indicate that the data were consistent with the null hypothesis and the binomial-likelihood model was used to test for differences in treatment effects, whereas a *P*-value < 0.10 was considered to be inconsistent with the null hypothesis of no overdispersion and the quasi-likelihood model was used to test for treatment differences instead. A *P*-value between 0.10 and 0.25 was considered inconclusive and both models were used. If the results of both models were in agreement, the less conservative binomial model was used, whereas if the results differed between models, the more conservative quasi-likelihood model was used and graphical examination of data was used to help explain the results. During the process of model fitting, deviance residuals were also graphed and examined for obvious outliers, skew, kurtosis, and heterogeneity of variation. In the cases where the quasi-likelihood form of the model were applicable, the standard errors were adjusted or scaled by multiplying by the square root of the ratio of the deviance and the degrees of freedom and the statistical significance of the models effects were based on the F-tests generated by SAS, rather than chi-square tests. Ninety-five percent profile- (log-ratio) or quasi-likelihood (over-dispersed model) confidence intervals were calculated for the overall odds ratio and single seasonal estimates of the passage indices for each comparison. Confidence intervals and *P*-values associated with the logistic regressions in this study do not account for the additional variation induced by adjusting the actual counts of fish passing via the various passage routes by a particular routes detection probability. However, since detection probabilities are generally very high for the various routes and few fish pass through areas with the lowest detection probability, differences between actual and adjusted counts are negligible and this additional variation should be small. Results of statistical tests throughout this report were considered statistically significant when $P < 0.05$.

Results from the Spring Study Period

Dam Operations

Percent spill and forebay elevation remained relatively constant, while total discharge and water temperature increased throughout the spring period. Overall, the mean percent day and night spill discharges were both 39%. The mean hourly day spill ranged from 38 to 41% and mean night spill ranged from 39 to 41% (Figure 4). About 98% of the spill was discharged through spill bays 1 through 6, 2% was discharged through bay 7, and less than 1% was discharged through bays 8 through 9 (Appendices D and G). Main turbine units 3, 4, 6, 7, and 10 were not operated during spring, while main units 1, 2, 5, and 8 were operated almost continuously (Appendices D and F). Main unit 18 at the upstream sluiceway entrance was operated 78% of the time. Mean project discharge ranged from 162 to 293 thousand cubic feet per second (kcfs) during the day and from 155 to 283 kcfs at night (Figure 4). Water temperature increased during the

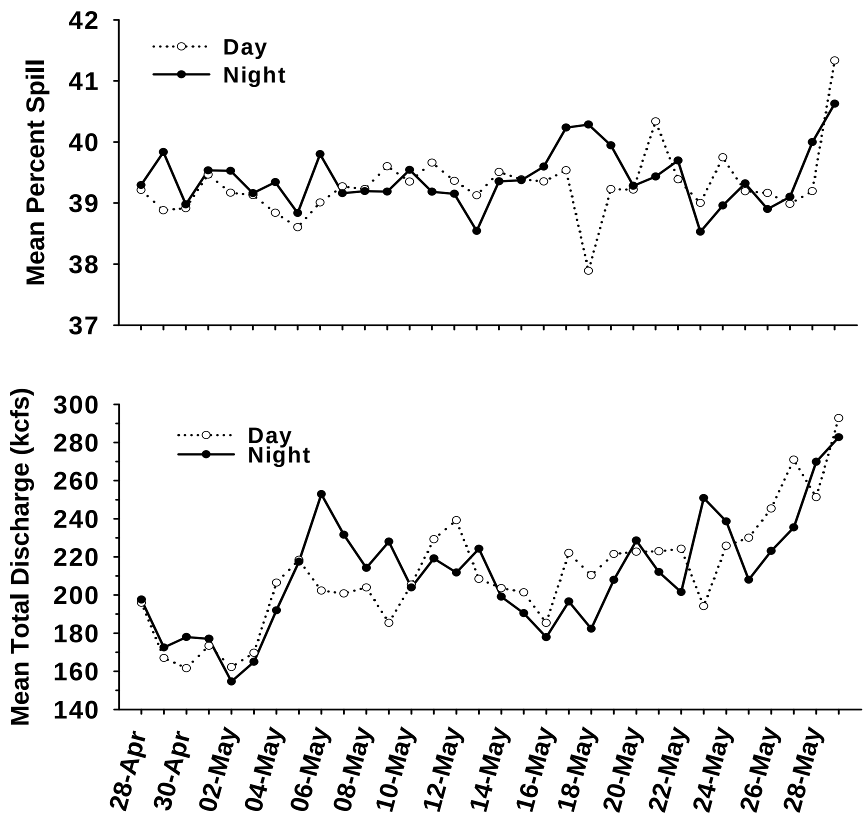


Figure 4. Mean day and night percent spill and total discharge at The Dalles Dam, spring 2004. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. kcfs = thousand cubic feet per second.

spring study period from about 12 to 15º C, while the forebay elevation remained relatively constant at about 158.5 ft (Figure 5).

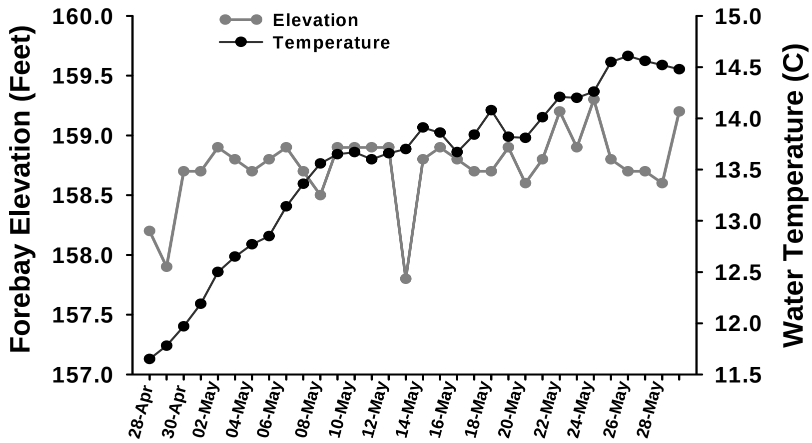


Figure 5. Elevation and water temperature at The Dalles Dam forebay during the spring 2004 release period. Data from University of Washington at http://www.cqs.washington.edu/dart/river.html.

Number of Fish Released and Detected

From 27 April through 28 May 2004, 2230 yearling Chinook salmon were radio-tagged and released in the John Day Dam tailrace (Appendix B). Prior to release, tagging and handling mortality was 0.8% and the tag regurgitation rate was 1.6%. Released fish had a mean fork length of 158 mm (124 to 230 mm) and a mean weight of 39.2 g (21.5 to 124.6 g). The mean tag weight to body weight ratio was 3.6% (range 1.1 to 6.5). Radio-tagged yearling Chinook salmon passed TDA between 28 April and 29 May 2004, representing 78% of the spring out migration (9th through 86th percentile, Figure 6 and Appendix C). Fish sampled by the Smolt Monitoring Facility during this period averaged 156 mm in length (114 mm to 221 mm). About 92.7% (N = 2068) of the released fish were detected in the TDA forebay and another 1.2% (N = 27) were detected only in the TDA tailrace. Sixty percent (N = 1338) of the released fish were detected at the upriver entrance and 63% (N = 1406) were detected at the downriver entrance.

Travel Time, Arrival Time, and Approach Pattern

The median travel time of yearling Chinook salmon from John Day Dam tailrace to TDA was 15.0 h (8 to 41 h) for both day and night releases. The hour of arrival at TDA was dispersed throughout the diel period due to variability in travel time among individuals and time of release but was distinctly bimodal. Peak times of arrival occurred at 0900 and 1900 hours (Figure 7). Seventy-five percent of the radio-tagged fish arrived during the day and 25% arrived at night.

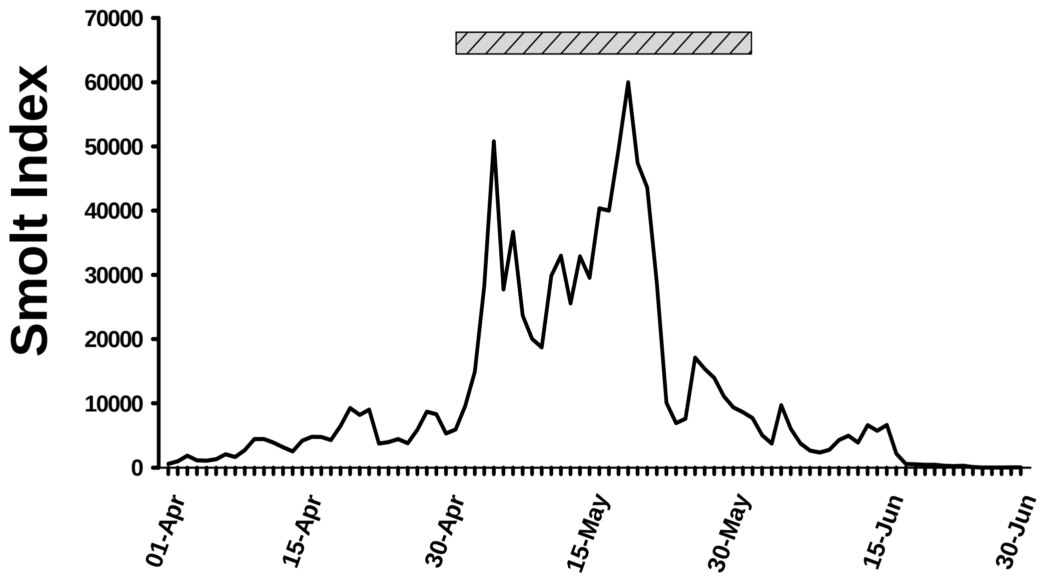


Figure 6. Yearling Chinook salmon smolt passage index at John Day Dam during 2004. Horizontal bar indicates spring study period. Data from University of Washington website at http://www. cqs.washington.edu/dart/river.html.

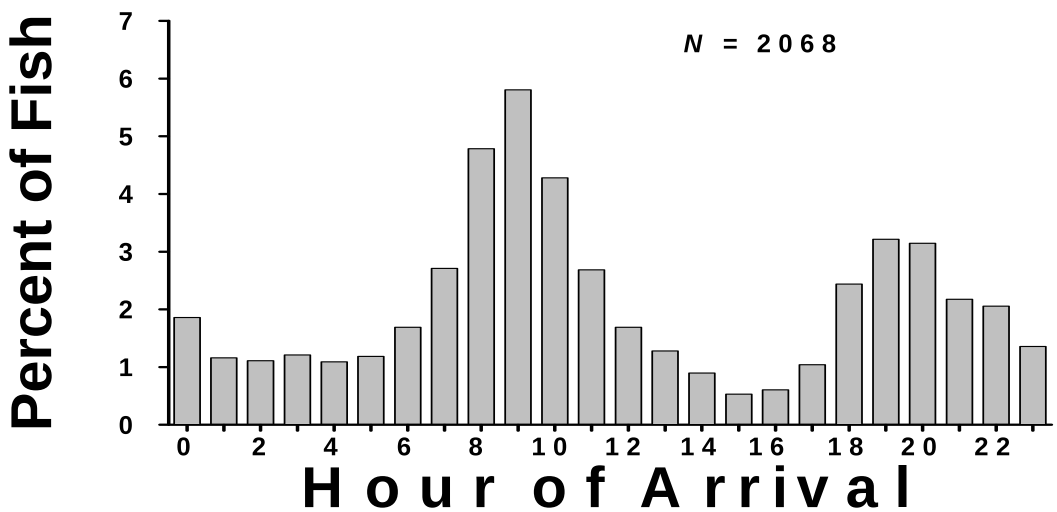


Figure 7. Hour of arrival of radio-tagged yearling Chinook salmon at The Dalles Dam, 28 April through 29 May 2004. Does not include 27fish only detected in the tailrace. Fish were released in the John Day Dam tailrace. *N* = sample size.

The horizontal distribution of radio-tagged fish at the upriver and downriver forebay entrances was similar during day and night periods, but differed between entrances (Figure 8). Overall, at the upriver entrance, 20% of the fish were located at the two southern locations and 80% were located at the two northern locations (primarily the barge north location), whereas at the downriver entrance, 43% of the fish passed the entrance at the southern locations and 57% at the northern locations.

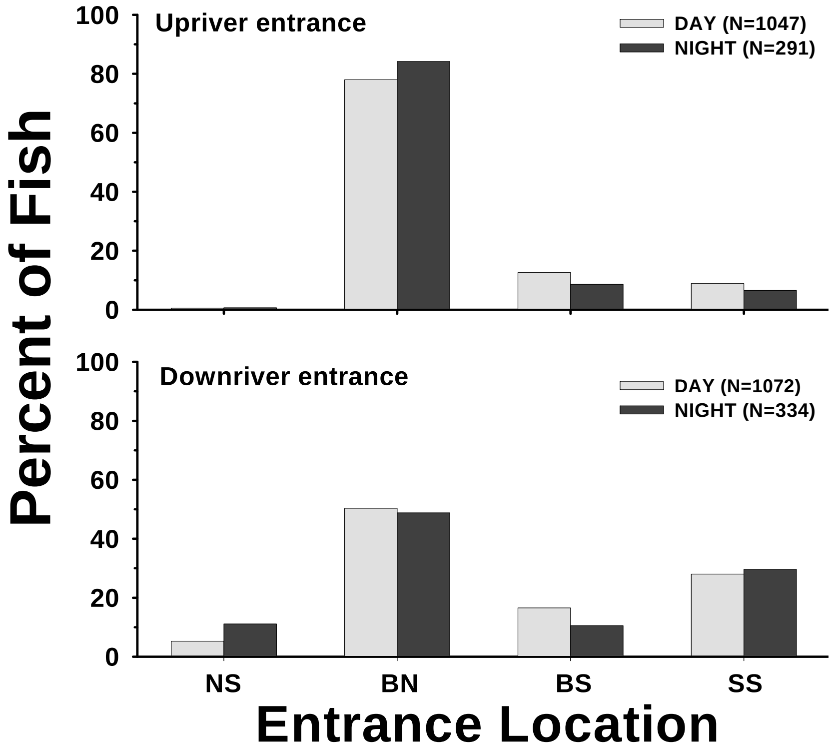


Figure 8. Horizontal location of radio-tagged yearling Chinook salmon detected at the upriver and downriver entrances above The Dalles Dam, 28 April through 29 May 2004. See Figure 2 for position of each location. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. *N* = sample size.

During the day and the night, generally fewer fish were first detected within 10 m of the dam at the powerhouse than the spillway (Figure 9). Overall, during the day, 30% of the fish first approached the dam at the powerhouse and 70% of the fish first approached at the spillway (Table 1). At night, 32% of the fish were first detected at the powerhouse and 68% were first detected at the spillway. The percentages of first detections at the powerhouse were higher at the west end (FU01 through MU11) than at the east end, while most first detections at the spillway were at the north end (spill bays 1

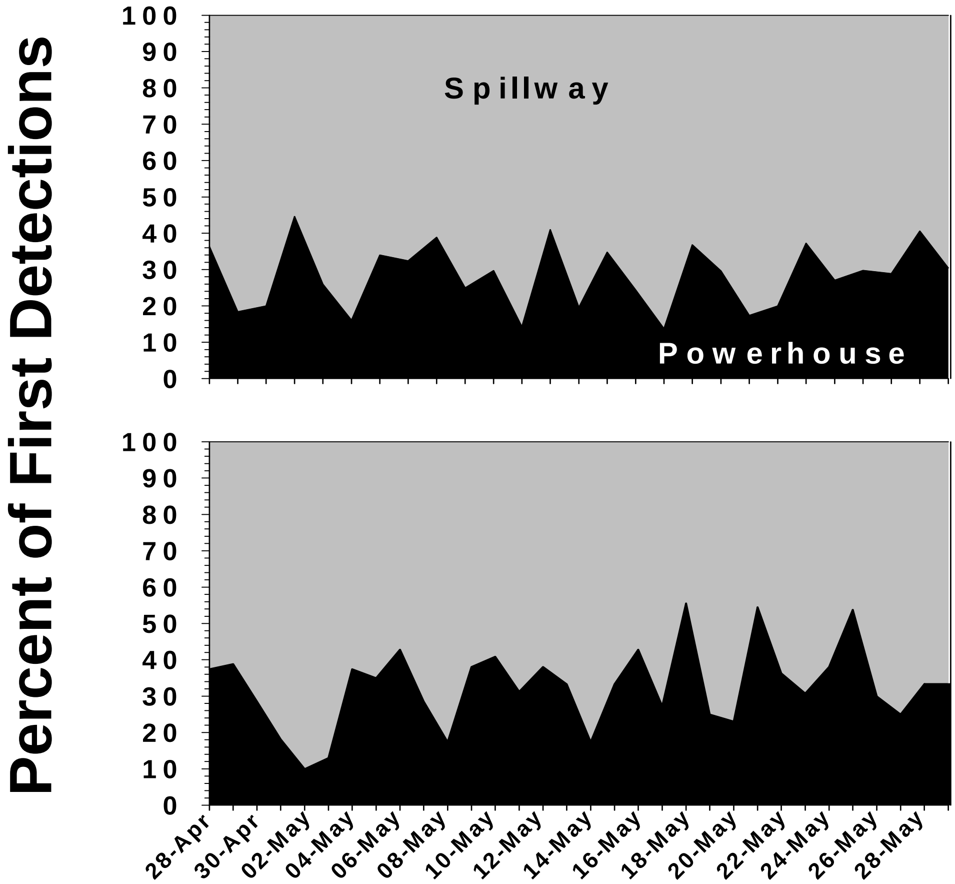


Figure 9. Percentage of radio-tagged yearling Chinook salmon first detected at the powerhouse (shaded black) and spillway (shaded gray) within 10 m of The Dalles Dam from 28 April through 29 May 2004. Day and Night refer to the hours from 0530 to 2059 and 2100 to 0529. Day sample sizes ranged from 32 to 59 and night sample sizes ranged from 6 to 26 per date.

Table 1. Percentages of yearling Chinook salmon first detections within 10 m of The Dalles Dam by forebay area, 28 April through 29 May 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529.

Forebay area	Day (%)	Night (%)
Fish Unit 1-Turbine Unit 11	19.9	23.2
Turbine Units 12-22	10.1	9.3
Spill Bays 1-12	61.4	60.8
Spill Bays 13-23	8.6	6.7

through 12; Figure 10). These distributions reflect the proportion of time that individual turbine units and tainter gates were discharging water during the study period (Appendix D through G) and differences in the volume of water spilled at individual tainter gates.

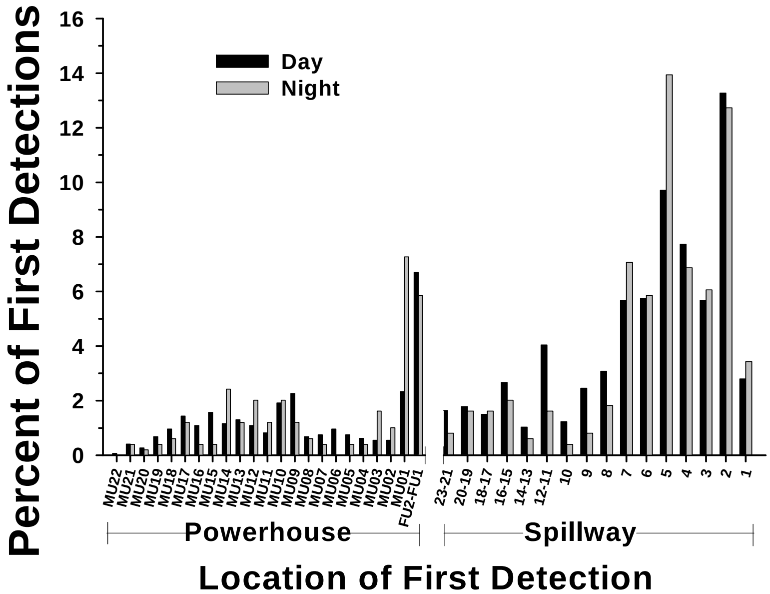


Figure 10. Percent of radio-tagged yearling Chinook salmon first detected within 10 m of The Dalles Dam at fish unit 1 through main turbine unit 22 at the powerhouse, and spill bays 23 through 1, 28 April through 29 May 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Sample sizes: 1459 day, 494 night. Turbine units are graphed from east to west. Spill bays are graphed from south to north.

Residence Times and Time of Passage

Median entrance and forebay residence times at TDA were less than 1.1 h during the day and night periods (Table 2). Overall, the median residence times for the diel periods pooled were as follows: upriver entrance 0.9 h, downriver entrance 0.6 h, forebay 0.3 h. The time of day that radio-tagged fish passed TDA was similar to the time of arrival due to the short period of residence. Seventy-three percent of the fish passed TDA during the day and 27% passed at night (Figure 11).

Table 2. Twenty-fifth, 50th (median), and 75th percentiles of radio-tagged yearling Chinook salmon entrance and forebay residence times (h) at The Dalles Dam by diel period, 28 April through 29 May 2004. Day and night, refer to the hours 0530 to 2059 and 2100 to 0529. Residence times were calculated from the first entrance or forebay time to the last forebay time. *N* = sample size.

	Day				Night			
Location	25th	Median	75th	N	25th	Median	75th	N
Upriver Entrance	0.68	0.83	1.05	951	0.86	1.07	1.43	370
Downriver Entrance	0.44	0.54	0.70	1007	0.55	0.74	1.01	387
Forebay	0.06	0.25	0.49	1503	0.06	0.27	0.61	565

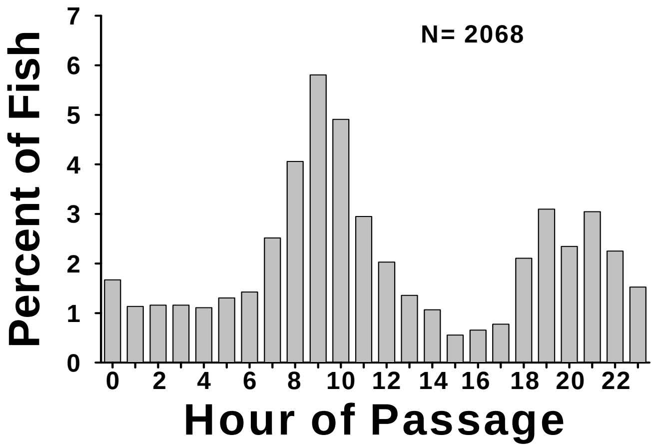


Figure 11. Hour of passage (2-h intervals) of radio-tagged yearling Chinook salmon at The Dalles Dam during 40% bulk spill discharge, 28 April through 29 May 2004. Fish were released in the John Day Dam tailrace. *N* = sample size.

Diel Detection Probabilities and General Route of Passage

Detection probabilities were high for all passage routes and had little effect on the observed frequencies of fish passing TDA via the three major passage routes. One fish detected passing via the Wasco County turbine at the north end of the spillway was excluded from these and later passage analyses. Diel detection probabilities were greater than 0.99 at the sluiceway and spillway and were 0.92 at the powerhouse (Table 3).

Table 3. Yearling Chinook salmon diel capture histories and detection probabilities at telemetry arrays at The Dalles Dam powerhouse, spillway, and sluiceway, 28 April through 29 May 2004. Capture history: 10 = number of fish detected only on array 1, 01 = number of fish detected only on array 2, 11 = number of fish detected only on array 1 and on array 2.

Capture History	Powerhouse		Spillway		Sluiceway	
	Day	Night	Day	Night	Day	Night
10	17	36	187	55	5	1
01	5	12	6	4	5	11
11	22	51	1180	337	87	73
Total	44	99	1373	396	97	85
Detection Probabilities						
P1	0.815	0.810	0.995	0.988	0.946	0.869
P2	0.564	0.586	0.863	0.860	0.946	0.986
P12	0.919	0.921	0.999	0.998	0.997	0.998

Differences in passage behavior of radio-tagged fish approaching the forebay at each of the 4 horizontal locations at the up- and downriver entrances were determined mainly by the diel period. For example, during the day, the proportion of fish passing via the turbines, sluiceway, and spillway varied little among the horizontal locations at the upriver entrance and few fish passed via the turbines. At night, turbine and sluiceway passage increased relative to the day, and generally decreased as the distance to a fish's entrance location from the powerhouse increased (Figure 12). At night, turbine passage ranged from 13 to 32%; sluiceway passage ranged from 17 to 23%, and; spillway passage ranged from 52 to 70% among upriver locations. Similar trends were observed for fish detected at the downriver entrance (Figure 13).

Diel differences in passage behavior were also evident for all radio-tagged yearling Chinook salmon detected at the dam. At night, proportionately more fish passed via the turbines and fewer fish passed through the spillway than during the day (Figure 14). Similar proportions of fish passed via the sluiceway during the day and night. Overall, during the day, 3% of the fish passed via the turbines, 6% passed through the sluiceway, and 90% passed via the spillway. At night, 18% passed via the turbines, 14% passed via the sluiceway, and 67% passed at the spillway.

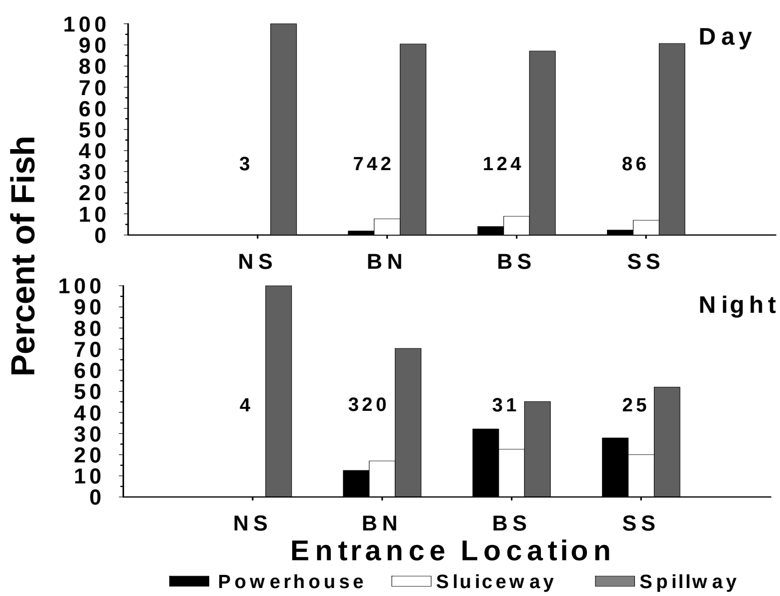


Figure 12. Yearling Chinook salmon passage at The Dalles Dam by upriver entrance location, 28 April through 29 May 2004. NS = north shore. BN = barge north. BS = barge south. SS = South shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Sample sizes shown near bars are adjusted for the detection efficiency of each passage route.

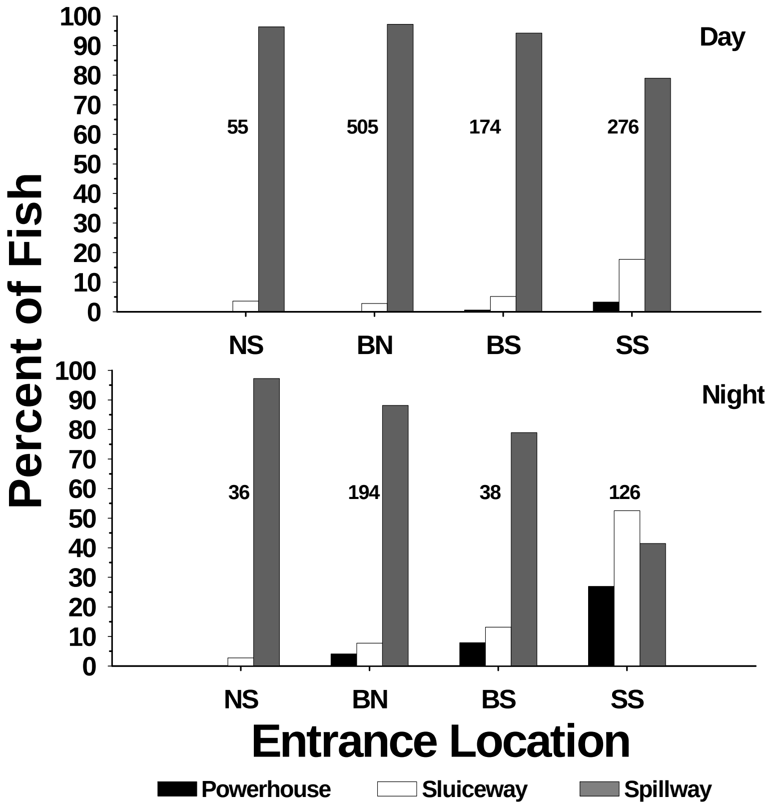


Figure 13. Yearling Chinook salmon distribution of passage through the powerhouse, sluiceway, and spillway at The Dalles Dam by passage location at the downriver entrance, 28 April through 29 May 2004. NS = north shore. BN = barge north. BS = barge south. SS = South shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Sample sizes are shown near bars for each downriver entrance passage location.

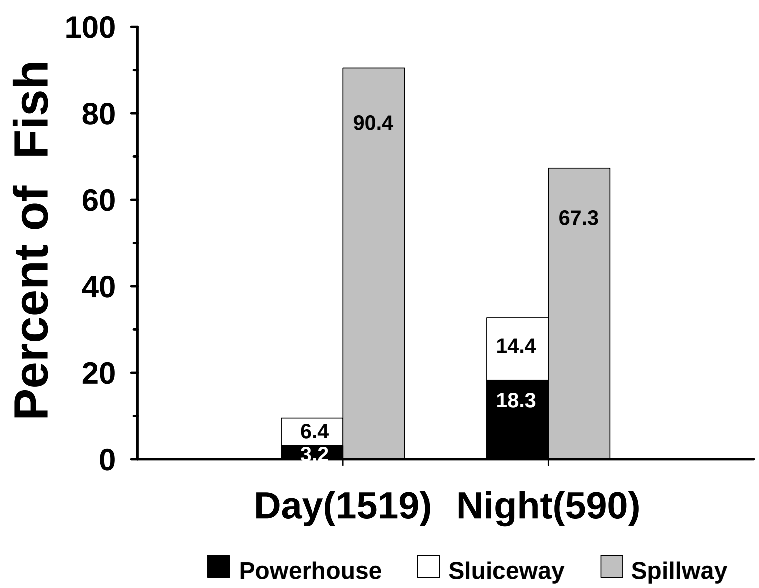


Figure 14. Radio-tagged yearling Chinook salmon passage by route at The Dalles Dam during 40% bulk spill discharge, 28 April through 29 May 2004. Passage percentages on the bar and sample sizes in parentheses have been adjusted for each routes detection efficiency. Day and night refer to the hours 0530 to 2059 and 2100 to 0529.

Most radio-tagged fish passing TDA via the turbines did so at the west and middle thirds of the powerhouse, while most spillway passage occurred north of the spill training wall (bays 1 through 6; Figure 15). These passage distributions reflect the percent of time individual turbines and tainter gates were in operation (Appendix D through G). Most radio-tagged fish passing TDA via the turbines went through units from MU14 to FU01, while most spillway passage occurred at spill bays 1 through 7 on the north end of the spillway where almost the entire spill was discharged (Figure 15). During day and night**,** 51 and 41% of the turbine passage was via FU01 through MU06, 35 and 13% passed through MU07 through MU14, and 14 and 9% of the fish passed through MU15 through MU22. At the spillway, the largest proportion of fish passed through spill bay 6 (23%) and the smallest proportion passed through spill bay 1 (6%). About 16% of the fish passed south of the spillway training wall at spill bay 7.

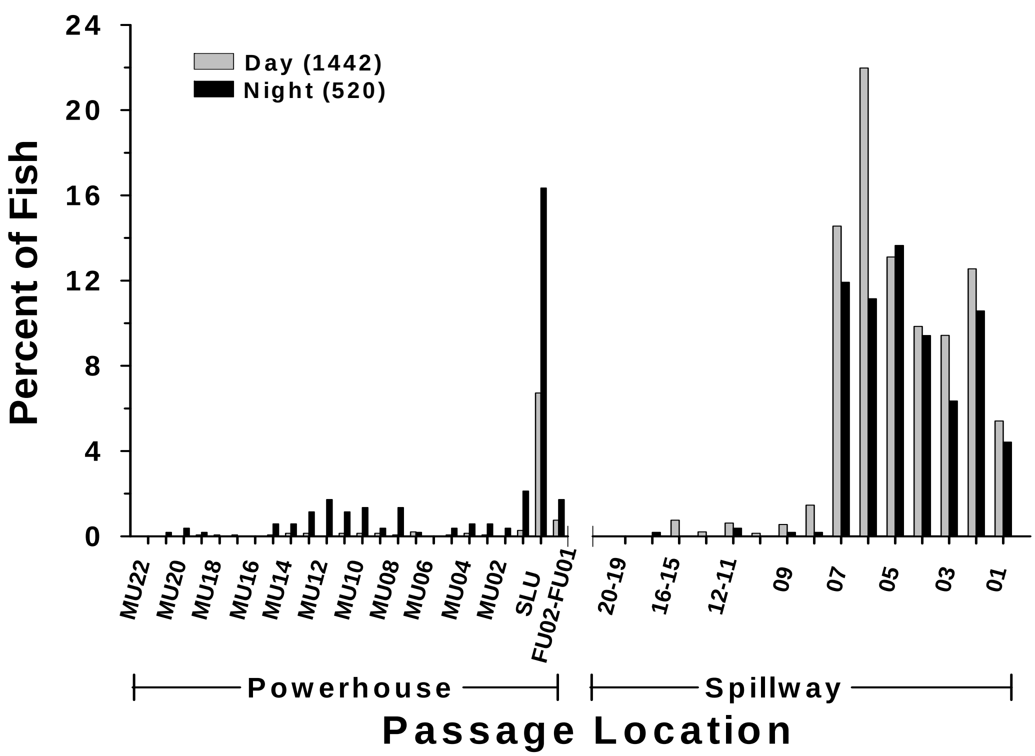


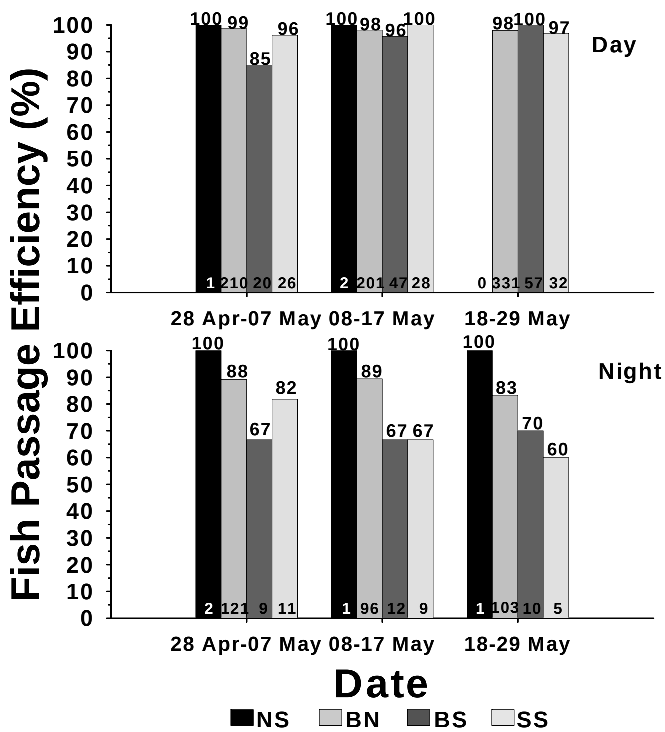
Figure 15. Radio-tagged yearling Chinook salmon passage via the powerhouse and the spillway during 40% bulk spill discharge at The Dalles Dam, 28 April through 29 June 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Passage locations based only on forebay underwater antennas and sluiceway aerial antennas. Sample sizes in parentheses. MU = main turbine unit. SLU = sluiceway. FU = fish turbine unit.

FPE, SPE, and SLPE Relative to Approach

Approach locations at the upriver entrance significantly differed in FPE and SPE at night, but not during the day (chi-square and F-tests, night all $P < 0.011$, day all $P > 0.45$, df = 2; Figures 16 and 17, Appendix H). At night, FPE and SPE were higher for fish entering the forebay via the more northern than southern routes (87 vs. 72% and 70 vs. 52%; Table 4). During the day, when no location effect was evident, FPE ranged from 96 to 98% and SPE ranged from 87 to 91% among fish located at each entrance location. Approach locations did not significantly differ in SLPE during day or night (chi-square and F-tests, all $P > 0.80$, df = 2; Figure 18, Appendix H), and ranged from 7 to 9% during the day and 17 to 23% at night among upriver entrance locations (Table 4).

At the downriver entrance to the forebay, there were differences in FPE and SPE, and SLPE among approach locations during the day and the night (chi-square tests, all $P < 0.0001$, df = 2; Figures 19 through 21, Appendix I). During the day, FPE and SPE were significantly less for fish entering the forebay near the south shore than via more northern approach routes (97 vs. 100% and 79 vs. 96%), while SLPE was significantly greater (18 vs. 3%; Table 5). Similar trends from south to north were observed at night, but the differences in FPE, SPE, and SLPE between fish approaching by northern and southern

Figure 16. Diel estimates of radio-tagged yearling Chinook salmon fish passage efficiency by upriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.



approach routes were greater than during the day. At night, FPE ranged from 73 to 96% among approach locations, SPE ranged from 40 to 97%, and SLPE ranged from 3 to 32%.

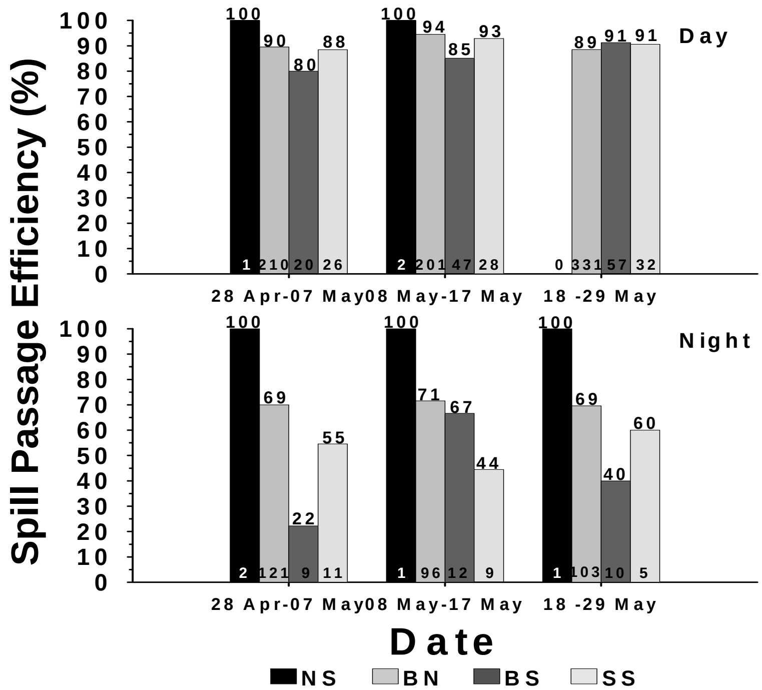


Figure 17. Diel estimates of radio-tagged yearling Chinook salmon spill passage efficiency by upriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS= south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.

Table 4. Diel fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE) estimates (Est) of yearling Chinook salmon detected at the upriver entrance by approach location during 40% bulk spill discharge at The Dalles Dam, 28 April through 29 May 2004. BN = barge north. BS = barge south. SS = south shore. *N* = sample sizes adjusted for detection efficiency. The NS was excluded from the analysis due to small sample sizes (Figure 16). CI = quasi-(^{Q}) or profile likelihood (^{B}) confidence interval estimates.

Passage efficiency	Approach location	Day Est %	Day 95% CI	Day *N*	Night Est %	Night 95% CI	Night *N*
FPE^{Q,B}	BN	98.0	96.3 - 99.0	742	86.6	82.5 - 90.0	320
	BS	96.0	89.6 - 99.0	124	67.7	50.3 - 82.3	31
	SS	97.7	90.7 - 99.8	86	72.0	52.8 - 86.9	25
SPE^{B,B}	BN	90.3	88.0 – 92.3	742	69.7	64.5 - 74.5	320
	BS	87.1	80.5 – 92.2	124	45.2	28.5 - 62.5	31
	SS	90.7	83.4 – 95.6	86	52.0	32.9 - 70.7	25
SLPE^{B,Q}	BN	7.7	5.9 - 9.7	742	16.9	11.5 - 23.3	320
	BS	8.9	4.7 - 14.7	124	22.6	6.8 - 47.0	31
	SS	7.0	2.8 - 13.6	86	20.0	4.4 – 47.0	25

Figure 18. Diel estimates of radio-tagged yearling Chinook salmon sluiceway passage efficiency by upriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.

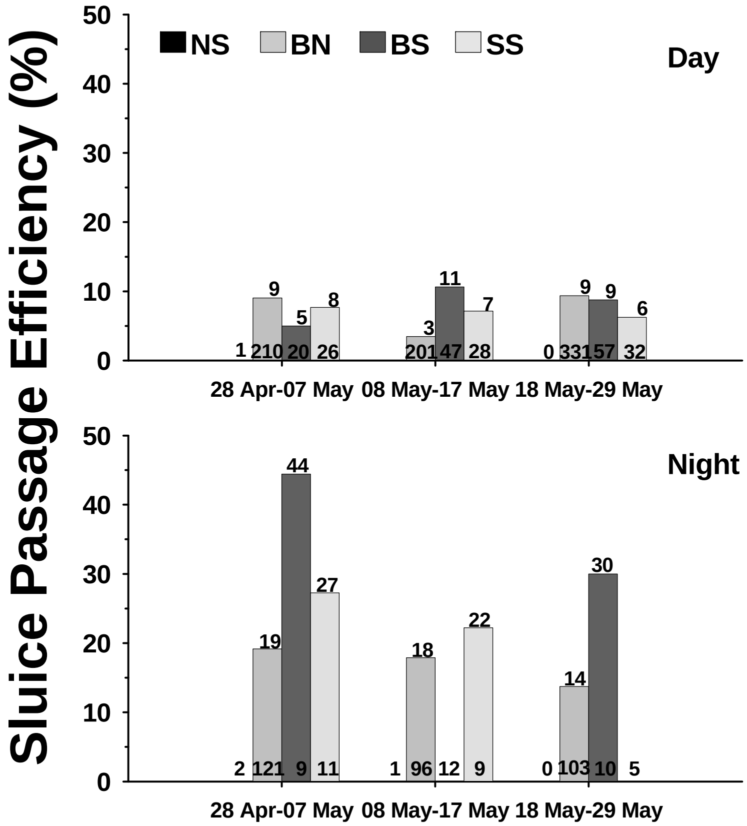


Figure 19. Diel estimates of radio-tagged yearling Chinook salmon fish passage efficiency by downriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.

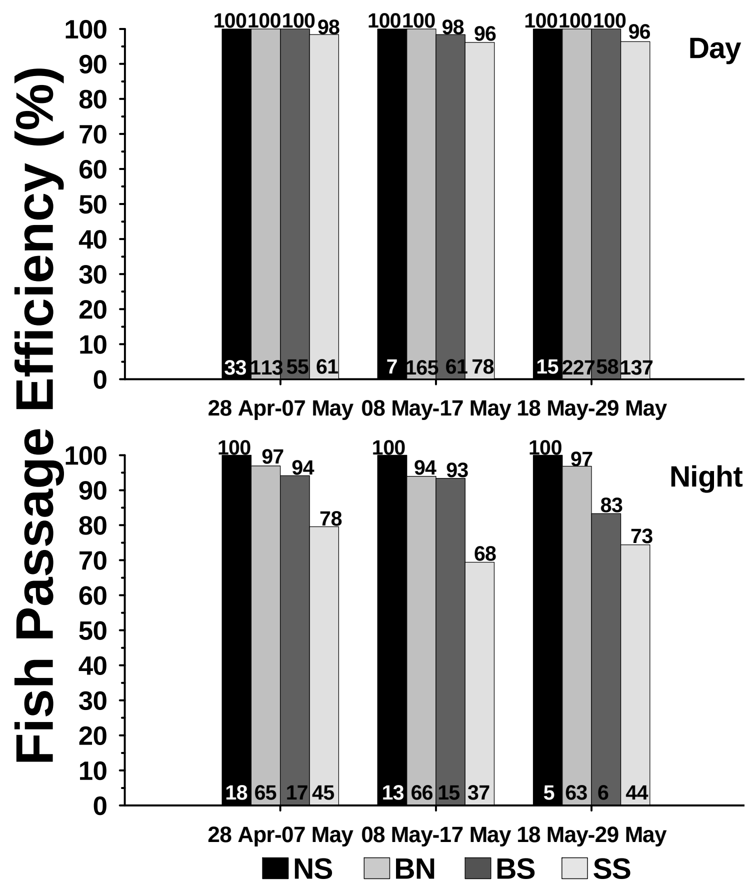


Figure 20. Diel estimates of radio-tagged yearling Chinook salmon spill passage efficiency by downriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.

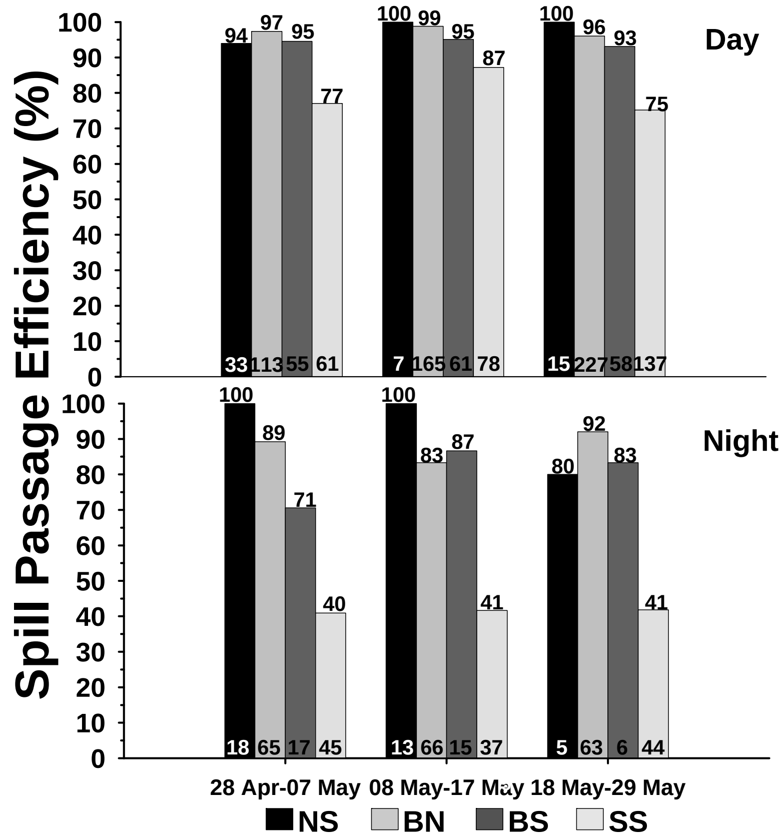


Figure 21. Diel estimates of radio-tagged yearling Chinook salmon sluiceway passage efficiency by downriver entrance location and seasonal period, spring 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Percentages above bars and sample sizes on bar have been adjusted for detection efficiency.

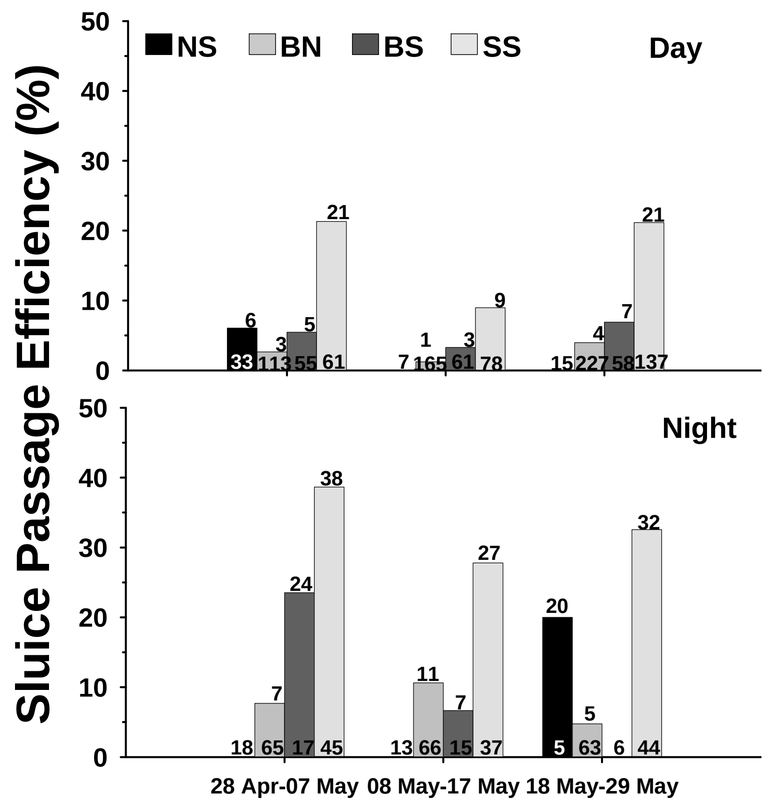


Table 5. Diel fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE) estimates (Est) of yearling Chinook salmon detected at the downriver entrance by approach location during 40% bulk spill discharge at The Dalles Dam, 28 April through 29 May 2004. BN = barge north. BS = barge south. SS = south shore. *N* = sample sizes adjusted for detection efficiency. CI = quasi-([Q]) or profile-likelihood ([B]) confidence interval estimates.

Passage efficiency	Approach location	Day			Night		
		Est %	95% CI	N	Est %	95% CI	N
FPE[B,B]	NS	100.0	100.0 - 100.0	55	100.0	100.0 - 100.0	36
	BN	100.0	100.0 - 100.0	505	96.5	92.5 - 98.1	194
	BS	99.4	97.5 - 100.0	174	92.1	80.8 - 98.0	38
	SS	96.7	94.2 - 98.4	276	73.0	64.8 - 80.2	126
SPE[Q,B]	NS	96.4	88.0 - 99.5	55	97.2	88.3 - 99.8	36
	BN	97.2	95.3 - 98.6	505	88.1	83.1 - 92.2	194
	BS	94.2	89.5 - 97.3	174	78.9	64.4 - 89.8	38
	SS	79.0	73.3 - 84.0	276	40.5	32.2 - 49.2	126
SLPE[Q,B]	NS	3.6	0.3 - 13.2	55	2.8	0.2 - 11.7	36
	BN	2.8	1.4 - 4.9	505	7.7	4.5 - 12.0	194
	BS	5.2	2.1 - 10.3	174	13.2	4.9 - 26.2	38
	SS	17.8	12.6 - 23.8	276	32.5	24.8 - 41.0	126

SLPE and FPE Relative to Sluiceway Operations

Operating a sluiceway entrance at the east and west ends of the powerhouse instead of operating only one entrance at the west end did not notably improve SLPE or FPE. Yearling Chinook salmon SLPE was 2.2% greater overall during the MU01 treatment than the MU01+MU18 treatment, while FPE was 0.4% less, but neither difference was statistically significant (chi-square and F-tests, $P = 0.07$ and 0.55, df=2; Figures 22 and 23 and Appendices J and K). SLPE and FPE were estimated to be 9.6 and 92.5% overall during the MU01 treatment and 7.4 and 92.9% during the MU01+MU18 treatment (Table 6). During the MU01+MU18 treatment, only 3% ($N = 2$) of the fish passing via the sluiceway entered through the MU18 entrance, while 97% ($N = 67$) of fish entered through the MU01 entrance.

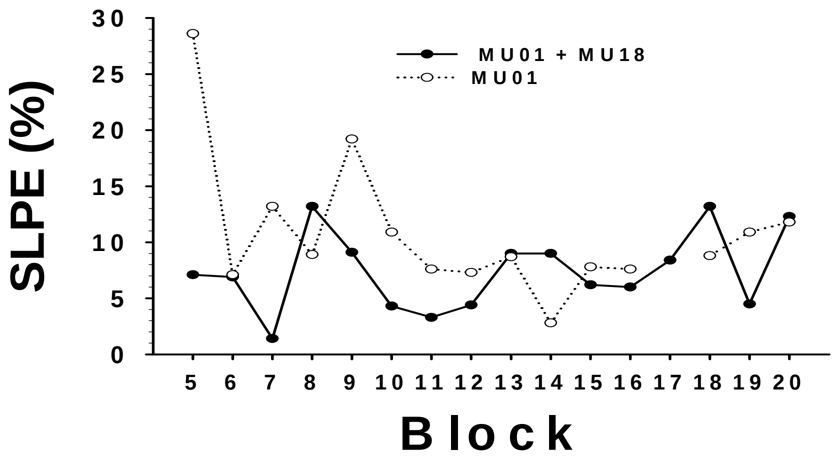


Figure 22. Sluiceway passage efficiency (SLPE) of yearling Chinook salmon by block and sluiceway treatment at The Dalles Dam, spring 2004. MU01 + MU18 = Main turbine unit (MU) 1 and 18 sluiceway entrances open. MU01 = MU01 sluiceway entrance open. Sample sizes are given in appendix J.

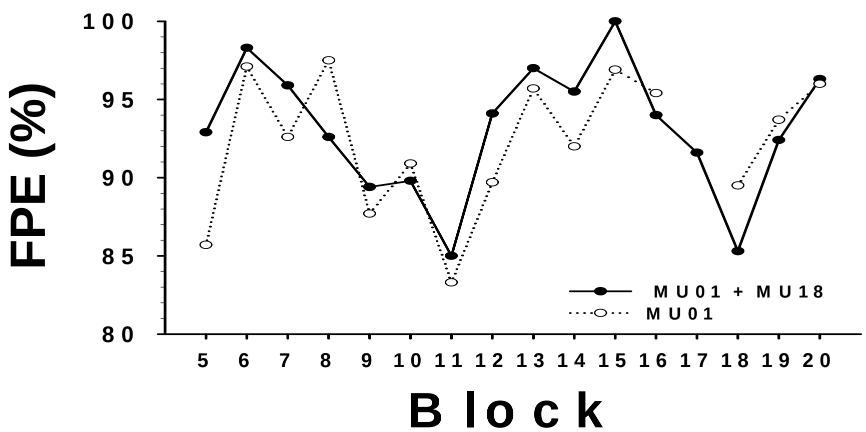


Figure 23. Fish passage efficiency (FPE) of yearling Chinook salmon by block and sluiceway treatment at The Dalles Dam, spring 2004. MU01 + MU18 = Main turbine unit (MU) 1 and 18 sluiceway entrances open. MU01 = MU01 sluiceway entrance open. Sample sizes are given in appendix K.

Table 6. Yearling Chinook salmon sluiceway (SLPE) and fish (FPE) passage efficiency point estimates (Est) during two sluiceway operation scenarios at The Dalles Dam, 28 April through 29 May 2004. MU01 = MU01 entrance open. MU01+MU18 = MU01 and MU18 entrances open. CI = quasi-(^{Q}) or profile-likelihood (^{B}) confidence interval estimates. *N* = sample sizes adjusted for sample size.

Passage	MU01 Treatment			MU01+MU18 Treatment		
efficiency	Est %	95% CI	*N*	Est %	95% CI	*N*
SLPE^{B}	9.6	7.8 - 11.6	953	7.4	5.9 - 9.1	1011
FPE^{Q}	92.5	89.7 - 94.7	953	92.9	90.3 - 95.0	1011

During the MU18+MU01 treatment, most radio-tagged fish detected within 10 m of the powerhouse first approached the dam downstream of the MU18 sluiceway entrance (Figure 24). About 7% of the fish were first detected from MU22 to MU18 and the remainder of first detections were about equally distributed among the four powerhouse areas from MU17 to MU12, MU11 to MU06, MU05 to MU01, and FU02 to FU01 (20 to 25%; Table 7). Some of these fish entered the turbines where they first approached the powerhouse or nearby turbines further downstream, but most fish passed through the spillway or the sluiceway entrance at MU01. Generally, greater than 52% of the fish that first approached one of these powerhouse areas passed via the spillway, except the fish that were first detected at the area from MU05 to MU01 (37%; Table 7). Concurrently, 14 to 25% of the fish approaching the powerhouse from MU22 to MU06 and FU02 to FU01 and 37% of the fish first detected at MU05 to MU01 passed via the MU01 sluiceway entrance. Thus, the fish entering the MU01 sluice entrance represented an aggregate of individuals whose first powerhouse detections were widely dispersed from MU22 to FU01. All fish entering the MU18 sluice entrance were first detected near the powerhouse at MU18 and represented 10% of all the fish first detected from MU22 to MU18. The

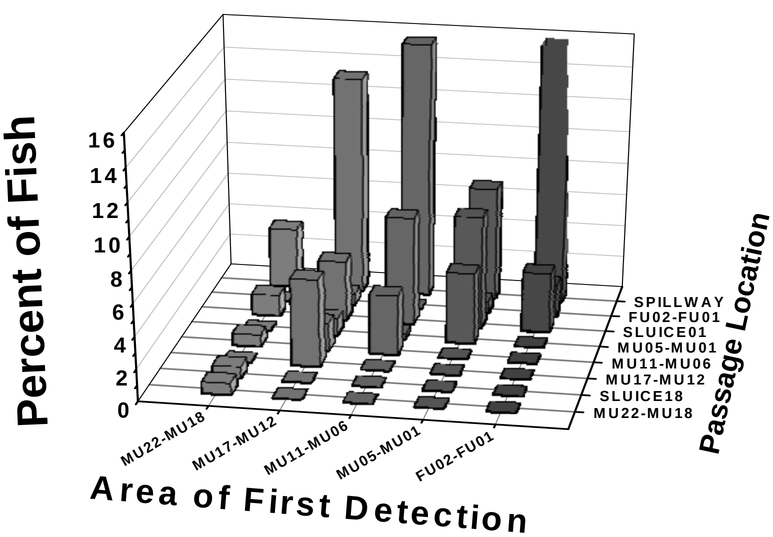


Figure 24. Percentage of yearling Chinook salmon first detected at various powerhouse main turbine unit (MU) areas that passed via the same turbine areas, MU18 sluiceway entrance, MU01 sluiceway entrance, Fish turbine units 01 and 02 or spillway when both the MU18 and MU01 sluiceway entrances were open at The Dalles Dam, 28 April through 29 May 2004. All 40 bars sum to 100%. Total sample size equals 299.

remaining fish not passing through the spillway or sluiceway passed through turbines at the powerhouse area where first detected (9 to 23%) or turbine areas downstream (0 to 13%). In general, fish were not detected passing upstream of where they were first detected. Overall, during the MU18+MU01 treatment, 56% of the fish first approaching near the dam at the powerhouse passed via the spillway, 22% passed via the sluiceway entrance at MU01, 21% passed via the turbines, and 1% passed via the sluiceway entrance at MU18. Radio-tagged fish first detected at the powerhouse during the MU01 treatment exhibited similar trends.

Table 7. Percentage of yearling Chinook salmon passage via various powerhouse main turbine unit (MU) areas, sluiceway entrances at MU18 or MU01, fish turbine units 01 and 02, or the spillway by area of first near-dam detection (<10 m) at The Dalles Dam, 28 April through 29 May 2004. MU18+MU01treatment = MU18 and MU01 sluiceway entrances open. MU01 treatment = only MU01 entrance open. *N* = sample size.

Passage Location	MU18+MU01 Treatment Area of First Near-Dam Detection (*N* = 299)					Percent of Total Passage
	MU22-18	MU17-12	MU11-06	MU05-01	FU02-01	
MU22-18	9.5	0.0	0.0	0.0	0.0	0.7
Sluice-18	9.5	0.0	0.0	0.0	0.0	0.7
MU17-12	0.0	20.8	0.0	0.0	0.0	5.3
MU11-06	9.5	6.5	13.9	0.0	0.0	6.0
MU05-01	0.0	3.9	1.3	22.8	0.0	5.7
Sluice-01	19.1	14.2	25.3	36.8	17.0	22.4
FU02-01	0.0	2.6	0.0	3.6	9.2	3.3
Spillway	52.4	52.0	59.5	36.8	73.8	55.9
Percent Total First Detections	7.1	25.7	26.4	19.1	21.7	

Passage Location	MU01 Treatment (*N* = 279) Area of First Near-Dam Detection					Percent of Total Passage
	MU22-18	MU17-12	MU11-06	MU05-01	FU02-01	
MU22-18	20.0	0.0	0.0	0.0	0.0	1.4
Sluice-18	0.0	0.0	0.0	0.0	0.0	0.0
MU17-12	5.0	16.0	0.0	0.0	0.0	4.3
MU11-06	0.0	4.3	16.7	0.0	0.0	5.4
MU05-01	0.0	1.4	5.6	12.1	0.0	4.3
Sluice-01	10.0	17.4	18.0	53.4	30.0	27.2
FU02-01	0.0	0.0	4.1	1.7	10.0	3.6
Spillway	65.0	60.9	55.6	32.8	60.0	53.8
Percent Total First Detections	7.2	24.7	25.8	20.8	21.5	

Total Project FPE, SPE, and SLPE

With few exceptions, radio-tagged yearling Chinook salmon FPE and SPE were greater during the day than the night, whereas SLPE was greater at night than during the day (Figure 25). These differences were statistically significant between the day and the night period (F-tests, all $P < 0.0001$, df = 1; Appendices L through N). Point estimates of FPE during day and night were 97 and 82%; estimates of SPE were 91 and 68%, and; estimates of SLPE were 6 and 14% (Table 8). Overall (pooled day and night), FPE was estimated to be 93%, SPE was estimated to be 84%, and SLPE was estimated to be 9%. Hourly FPE estimates for spring indicated that turbine passage was relatively higher between 2100 and 0459 hours (range: 14 to 30%) than between 0500 and 2059 hours (range: 0 to 8%), resulting in diel differences in FPE (Figure 26). Yearling Chinook salmon spill effectiveness was 2.3 during the day, 1.7 at night, and 2.2 overall.

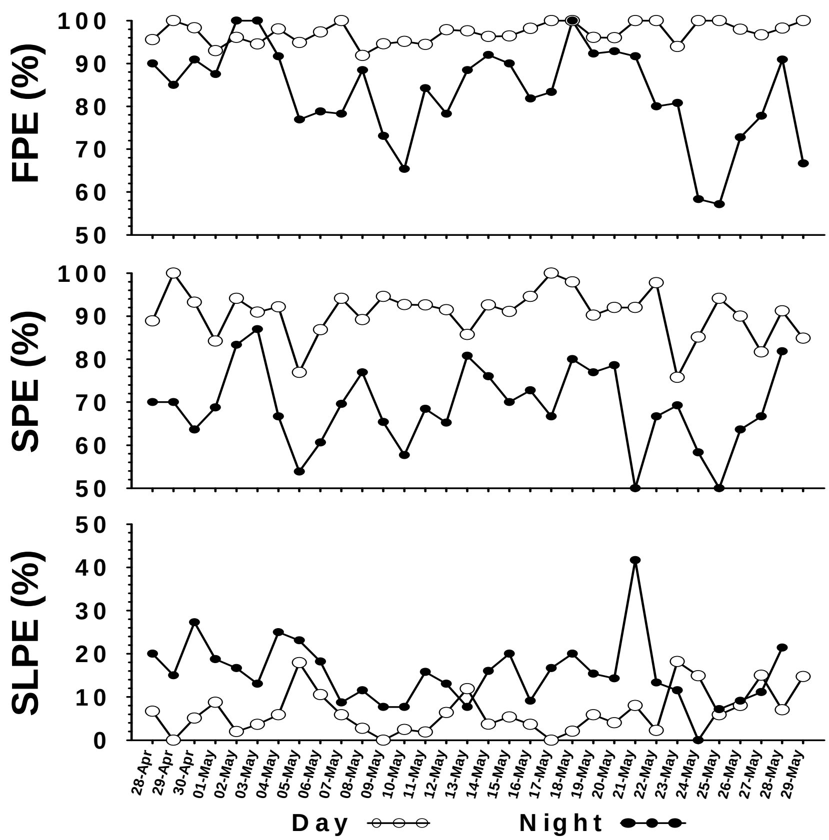


Figure 25. Daily diel estimates of radio-tagged yearling Chinook salmon fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, SLPE), 28 April through 29 May 2004. Efficiency estimates are expressed as a percent. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Sample sizes are given in appendices L through N.

Table 8. Diel and overall fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) estimates of yearling Chinook salmon detected at The Dalles Dam during 40% bulk spill discharge, 28 April through 29 May 2004. QRCI = quasi-likelihood ratio confidence interval. *N* = sample sizes adjusted for detection efficiencies. An asterisk (*) indicates a significant difference between day and night estimates at the $\alpha = 0.05$ level. See appendices L through N.

Diel period	Passage efficiency	Estimates %	95% QRCI	*N*
Day	FPE*	97.1	96.0 - 98.0	1514
	SPE*	90.7	88.8 - 92.3	1514
	SLPE*	6.4	5.0 - 8.0	1514
Night	FPE	81.9	78.0 - 85.5	587
	SPE	67.5	62.8 - 71.9	587
	SLPE	14.5	11.3 - 18.1	587
Overall	FPE	92.9	90.6 - 94.7	2101
	SPE	84.2	81.0 - 87.1	2101
	SLPE	8.7	7.1 - 10.4	2101

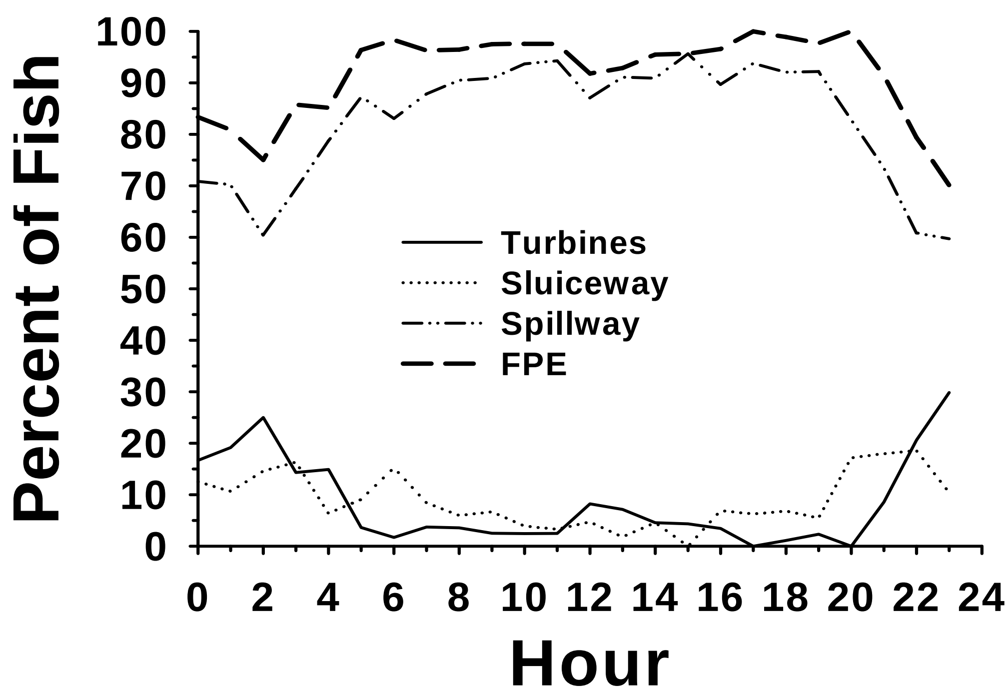


Figure 26. Yearling Chinook salmon powerhouse, sluiceway, and spillway passage, and fish passage efficiency (FPE) by hour at The Dalles Dam, 28 April through 29 May 2004. Sample size equals 2094.

Results from the Summer Study Period

Dam Operations

The observed mean day and night percent spill levels were similar during the summer period. Overall, the mean hourly percent spill discharge during the day was 39% and at night it was 40%. The mean day percent spill discharges ranged from 28 to 40% and mean night percent spill ranged from 34 to 42% (Figure 27). About 95% of the spill was discharged through spill bays 1 through 6, 3% was discharged through bay 7, and 2% was discharged through bays 8 through 10. Total project discharge decreased over the summer period (Figure 27). Mean total discharge ranged from 101 to 216 thousand cubic feet per second (kcfs) during the day and from 108 to 216 kcfs at night. Overall, total discharge averaged 163 kcfs during the day and 140 kcfs at night. Water temperature increased during the summer study period from about 16.5 to 22.5 C, while the forebay elevation remained relatively constant at about 158.5 feet (Figure 28).

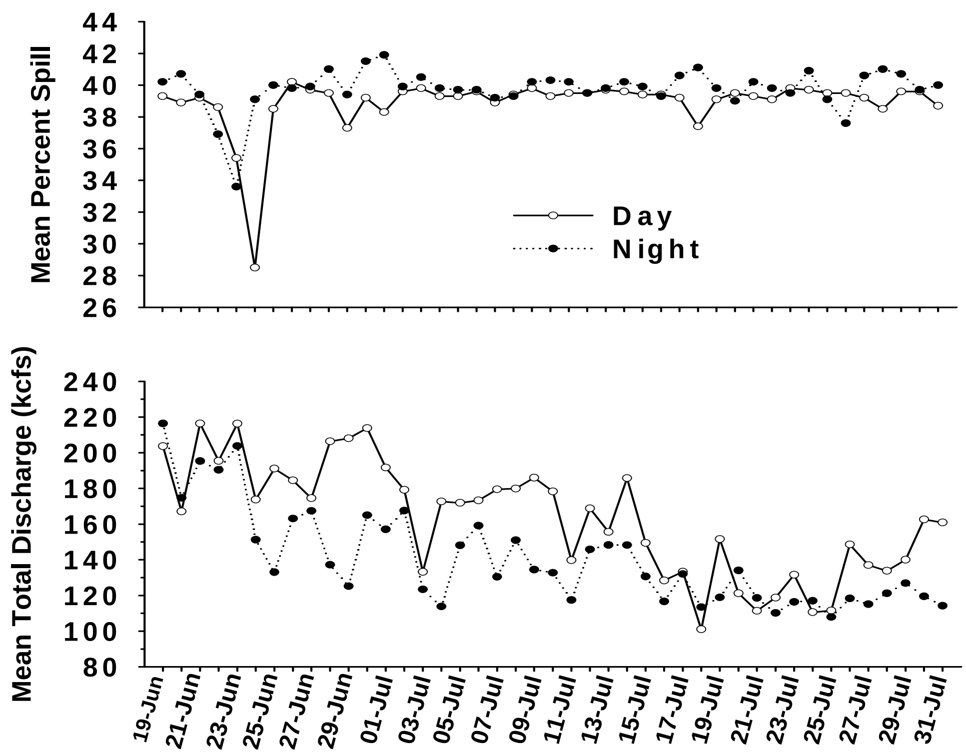


Figure 27. Day and night mean percent spill and total discharge at The Dalles Dam, 19 June through 31 July 2004. kcfs = thousand cubic feet per second. Day and night refer to the hours 0530 to 2059 and 2100 to 0529.

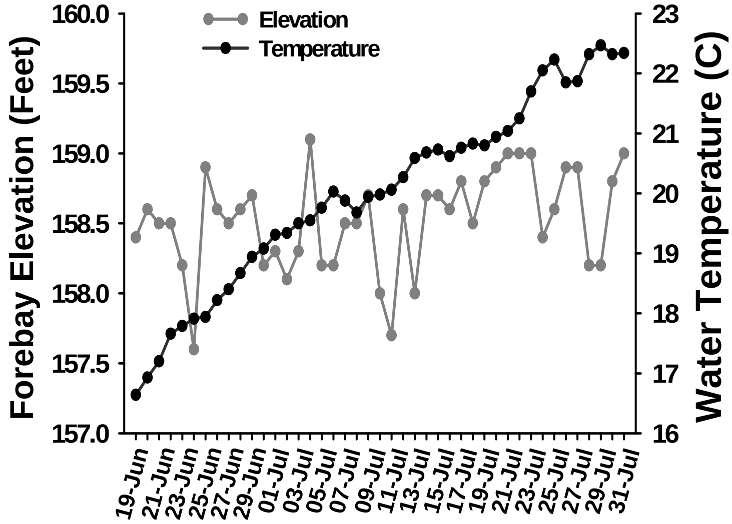


Figure 28. Elevation and water temperature at The Dalles Dam forebay during the summer 2004 release period. Data from University of Washington at http://www.cqs.washington. edu/dart/river.html.

Number of Fish Released and Detected

From 19 June through 28 July 2004, 2210 subyearling Chinook salmon were radio-tagged and released in the JDA tailrace. Prior to release, 19 June through 14 July, tagging and handling mortality was 1.8% and the tag regurgitation rate was 1.3%. After 14 July, when water temperatures were higher, tagging and handling mortality was 5.0% and the tag regurgitation rate was 5.7%. Radio-tagged fish had a mean fork length of 115 mm (100 to 175 mm) and a mean weight of 17g (13 to 56 g; Appendix O). The mean tag weight to body weight ratio was 5.0% (1.5 to 6.5%). The summer results are based on subyearling Chinook salmon of unknown origin passing TDA between 19 June and 29 July 2004, corresponding with 80% of the summer out migration (13th through 93rd percentile, Appendix P and Figure 29). Fish sampled by the Smolt Monitoring Facility during this period averaged 98 mm in length (61 mm to 68 mm). Eighty-three percent of these fish were detected at TDA, 54% were detected at the upriver entrance, and 53% were detected at the downriver entrance to the TDA forebay.

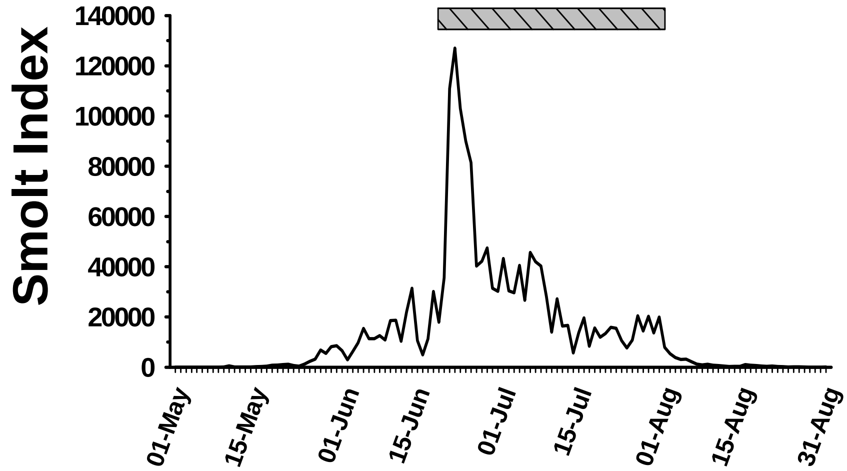


Figure 29. Subyearling Chinook salmon smolt passage index at John Day Dam during 2004. Horizontal bar indicates spring study period. Data from University of Washington website at http://www.cqs. washington.edu/dart/river.html.

Travel Time, Arrival Time, and Approach Pattern

The median travel time of subyearling Chinook salmon released in the JDA tailrace to the TDA forebay was 17 h (9 to 101 h). Due to the variability in travel time among individuals and day and night release times, the hour of arrival at TDA was dispersed throughout the diel period with modes at 1000 and 2000 hours (Figure 30). Seventy-four percent of the radio-tagged fish arrived during the day and 26% arrived at night.

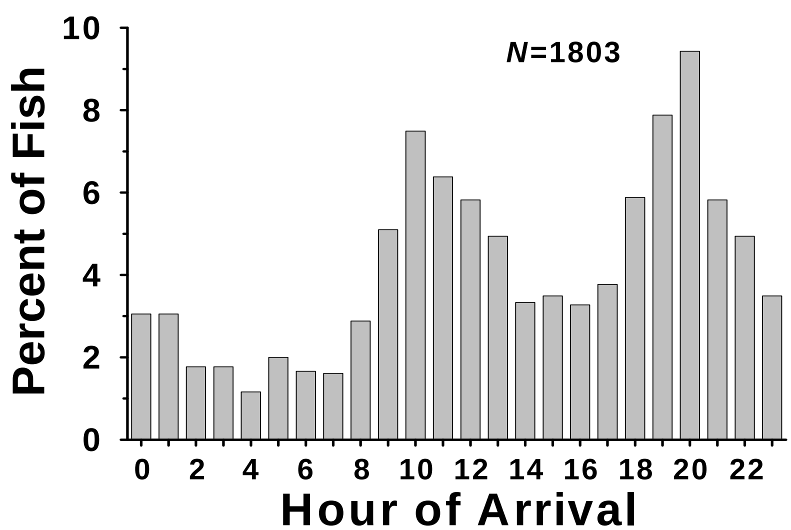


Figure 30. Hour of arrival (2-h intervals) of radio-tagged subyearling Chinook salmon at The Dalles Dam, 19 June through 29 July 2004. *N* = sample size.

The horizontal distribution of subyearling Chinook salmon differed between upriver and downriver entrances, but was similar at each entrance between diel periods (Figure 31). Most fish passed at the barge north location (62%) at the upriver entrance, with decreasingly fewer fish passing at the barge south (24%), south shore (13%), and north shore locations (1%). At the downriver entrance, fish passed in about equal numbers at the barge north (43%) and south shore (44%) locations, with fewer fish passing at the barge south (8%) and north shore (5%) locations.

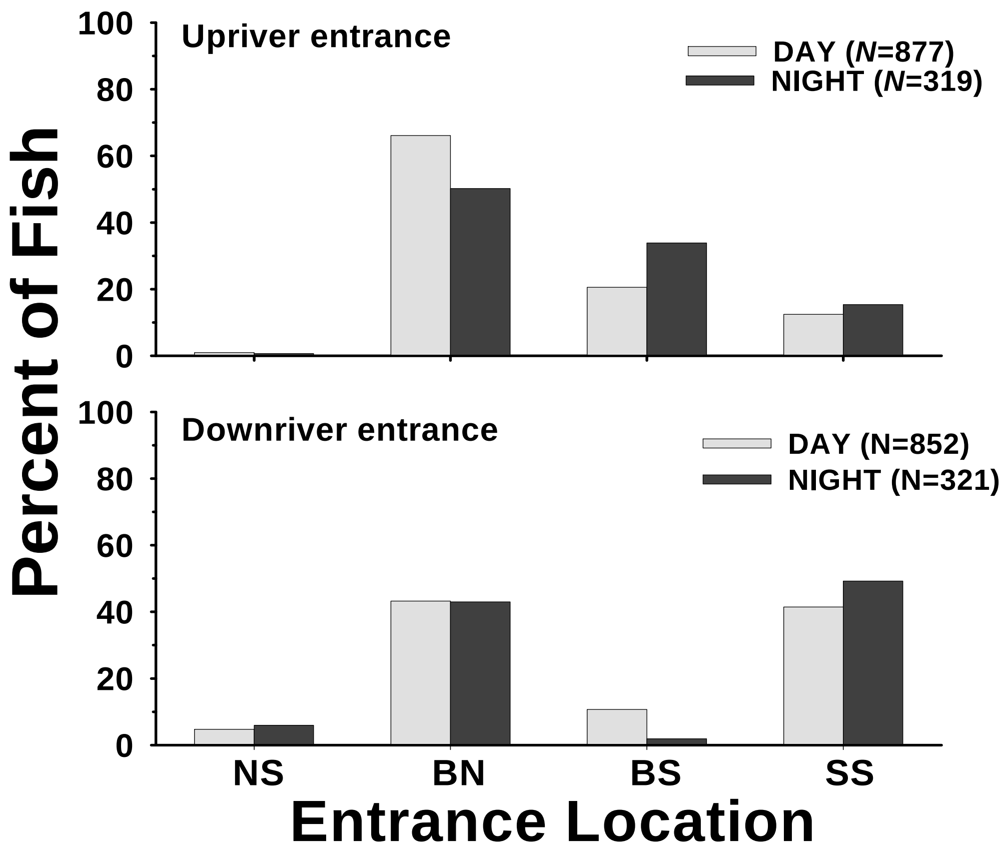


Figure 31. Horizontal location of radio-tagged subyearling Chinook salmon detected at the upriver and downriver entrances above The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. *N* = sample size.

Within 10 m of the dam, more fish first approached at the spillway during both day and night than at the powerhouse (Figure 32). Most of these fish were first detected at the northern half of the spillway (bays 1 through 12) and western half of the powerhouse (FU01 through MU11; Figure 33). Overall, during the day, 62% of the fish were first

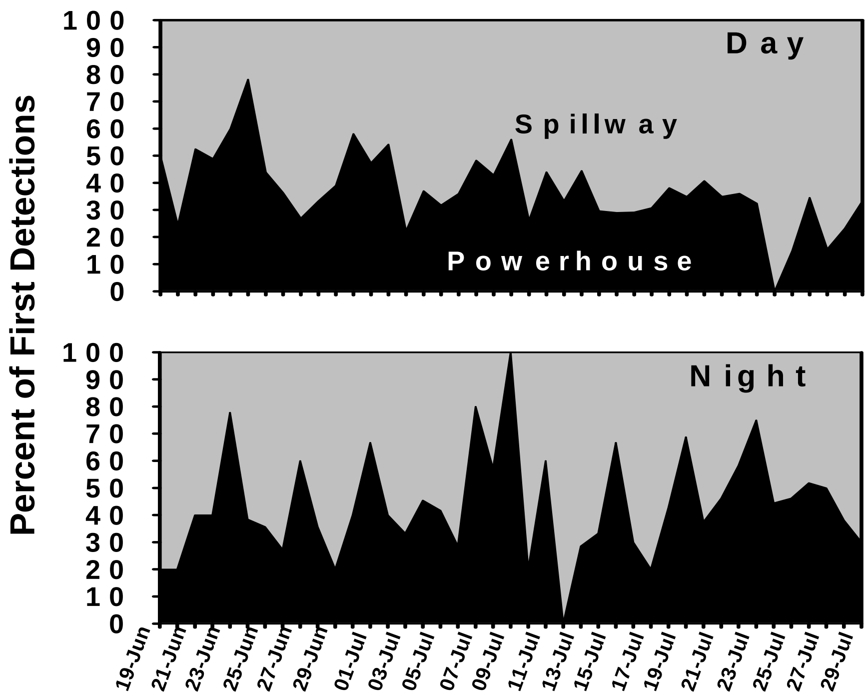


Figure 32. Percent of subyearling Chinook salmon first detections within 10 m of the dam at the powerhouse and spillway of The Dalles Dam during day and night, 19 June through 29 July 2004. Day and night refer the hours from 0530 to 2059 and 2100 to 0529. Sample sizes ranged from 6 to 45 during the day and from 5 to 27 at night per date.

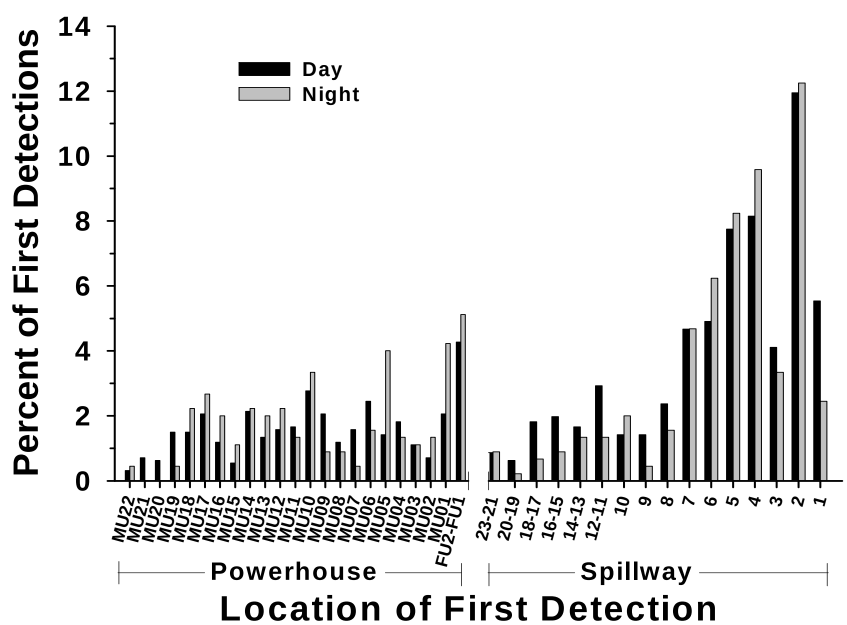


Figure 33. Percent of radio-tagged subyearling Chinook salmon first detected on forebay underwater antennas within 10 m of The Dalles Dam at fish units 1 and 2 (FU01 - FU02) and main turbine units 1 through 22 (MU01 - MU22) at the powerhouse and spill bays 23 through 1, 19 June through 29 July 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Sample sizes: 1264 day, 449 night. Turbine units are graphed from east to west. Spill bays are graphed from south to north.

detected at the spillway and 38% were first detected at the powerhouse (Table 9). At night, 56% of the fish were first detected at the spillway and 44% were first detected at the powerhouse. These distributions reflect the proportion of time that individual turbine units and tainter gates were discharging water during the study period (Appendices Q through T).

Table 9. Percentage of subyearling Chinook salmon first detections by forebay area at The Dalles Dam, 19 June through 29 July 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529.

Forebay area	Day (%)	Night (%)
Fish Unit 1 - Turbine Unit 11	24	28
Turbine Units 12 - 22	14	16
Spill Bays 1 - 12	55	52
Spill Bays 13 - 23	7	4

Residence Times and Time of Passage

Median upriver entrance, downriver entrance, and forebay residence times at TDA did not exceed 1.4 h during the day or night (Table 10). Consequently, the hour of passage and arrival were similar. The time of day that radio-tagged fish passed TDA was affected by release times and individual travel times from the release site. Seventy-one percent of the fish passed TDA during the day and 29% passed at night (Figure 34).

Table 10. Twenty-fifth, 50^{th} (median), and 75^{th} percentiles of radio-tagged subyearling Chinook salmon entrance and forebay residence times (h) at The Dalles Dam by diel period, 19 June through 29 July 2004. Day and night, refer to the hours 0530 to 2059 and 2100 to 0529. Residence times were calculated from the first entrance or forebay time to the last forebay time. *N* = sample size.

	Day				Night			
Location	25^{th}	Median	75^{th}	*N*	25^{th}	Median	75^{th}	*N*
Upriver Entrance	0.71	0.86	1.13	794	1.00	1.36	1.90	367
Downriver Entrance	0.46	0.57	0.77	782	0.58	0.85	1.37	372
Forebay	0.06	0.26	0.51	1289	0.08	0.31	0.80	514

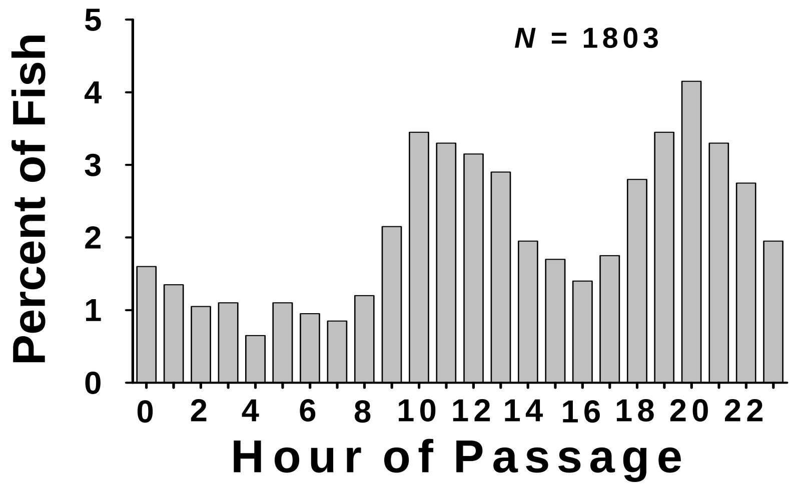


Figure 34. Hour of passage (2-h intervals) of radio-tagged subyearling Chinook salmon at The Dalles Dam during 40% bulk spill discharge, 19 June through 29 July 2004. Fish were released in the John Day tailrace. *N* = sample size.

Diel Detection Probabilities and General Route of Passage

Detection probabilities were high for all passage routes and had little effect on the observed frequencies of fish passing via each of them. Diel detection probabilities at the spillway and sluiceway were greater than 0.99 during the day and the night, whereas at the powerhouse they were 0.99 during the day and 0.92 at night (Table 11).

Table 11. Subyearling Chinook salmon diel capture histories and detection probabilities for telemetry arrays at The Dalles Dam powerhouse, spillway, and sluiceway, 19 June through 29 July 2004. Capture history: 10 = number of fish detected only on array 1, 01 = number of fish detected only on array 2, 11 = number of fish detected on array 1 and on array 2.

	Powerhouse		Spillway		Sluiceway	
Capture History	Day	Night	Day	Night	Day	Night
10	42	55	36	19	2	1
01	1	28	14	3	0	0
11	47	100	1076	304	86	35
Total	90	183	1126	326	88	36
Detection Probabilities						
P1	0.979	0.781	0.987	0.990	1.000	1.000
P2	0.528	0.645	0.968	0.941	0.977	0.972
P12	0.990	0.922	0.999	0.999	1.000	1.000

Differences in passage behavior of radio-tagged fish approaching the forebay at each of the 4 horizontal locations at the up- and downriver entrances were determined mainly by the diel period. During the day, a fish's horizontal location had little effect on passage location, whereas at night, the proportion of fish passing via the spillway increased with distance from the powerhouse and concurrent turbine passage decreased (Figures 35 and 36). The proportion of sluiceway passage remained relatively constant across locations during both day and night. At night, turbine passage ranged from 25 to 52%; sluiceway passage ranged from 6 to 9%, and; spillway passage ranged from 39 to 69% among downriver locations. Similar trends were observed for fish detected at the upriver entrance, but the differences among locations for each passage route were greater.

Diel differences in passage behavior were also evident for all radio-tagged subyearling Chinook salmon detected at the dam. Turbine passage was 28% greater and spill passage 28% less at night than during the day (Figure 37).

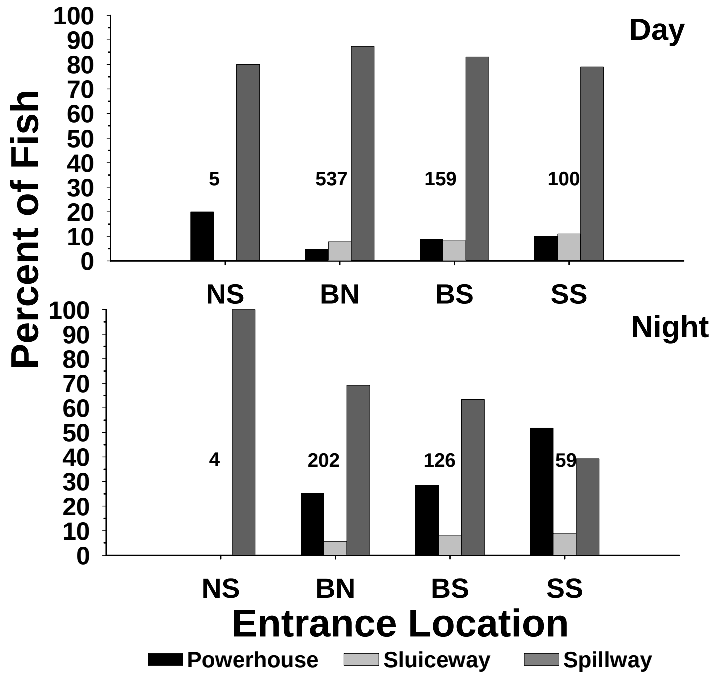


Figure 35. Distribution of subyearling Chinook salmon passage through the powerhouse, sluiceway, and spillway at The Dalles Dam by upriver entrance passage location, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Sample sizes adjusted for detection efficiency are shown above bars for each approach location.

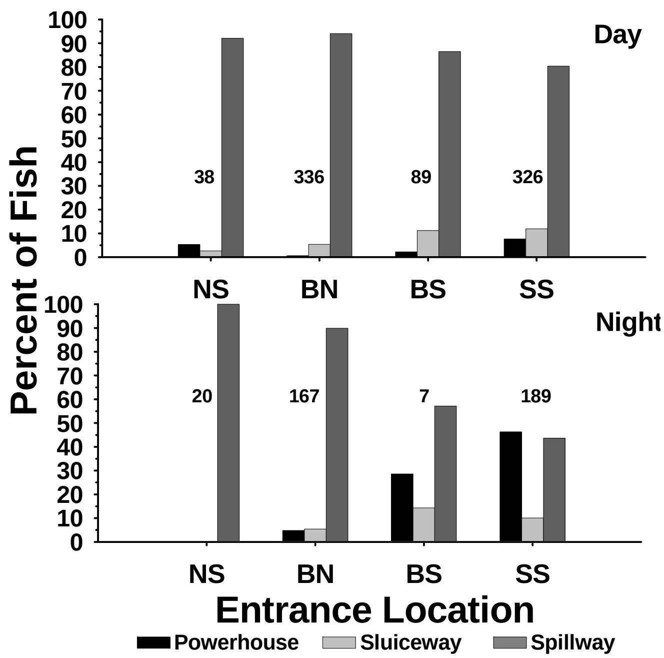


Figure 36. Distribution of subyearling Chinook salmon passage through the powerhouse, sluiceway, and spillway at The Dalles Dam by downriver entrance passage location, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Sample sizes adjusted for detection efficiency are shown above bars for each approach location.

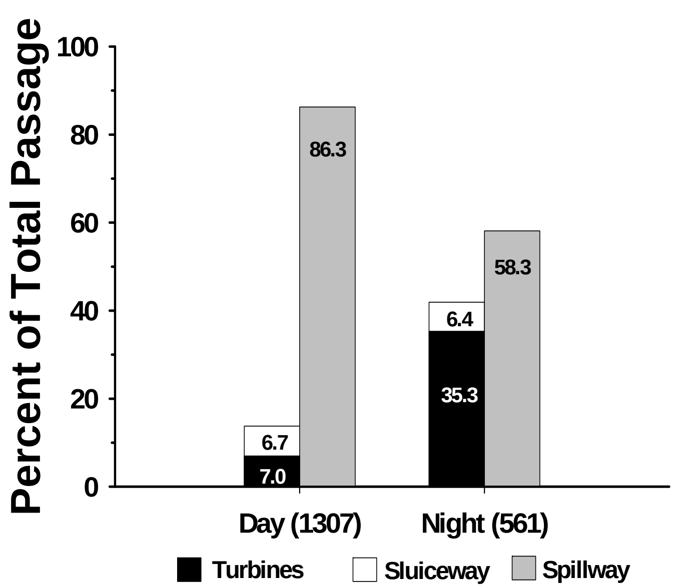


Figure 37. Radio-tagged subyearling Chinook salmon passage at The Dalles Dam during 40% bulk spill discharge, 19 June through 29 July 2004. Specific passage percentages for each route are shown on each bar. Sample sizes adjusted for detection efficiencies are in parentheses. Day and night refer to the hours 0530 to 2059 and 2100 to 0529.

Most radio-tagged fish passing TDA via the turbines went through FU01 to MU14, while most spillway passage occurred at spill bays 1 through 6 on the north side of the spillway training wall where most spill was discharged (Figure 38). During day and night**,** thirty-one and 45% of the turbine passage was via FU01 through MU06, 49 and 46% passed through MU07 through MU14, and 20 and 9% of the fish passed through MU15 through MU22, respectively. At the spillway, the largest proportion of fish passed through spill bay 6 (23%) and the smallest proportion passed through spill bay 1 (8%). About 9% of the fish passed south of the training wall at spill bay 7.

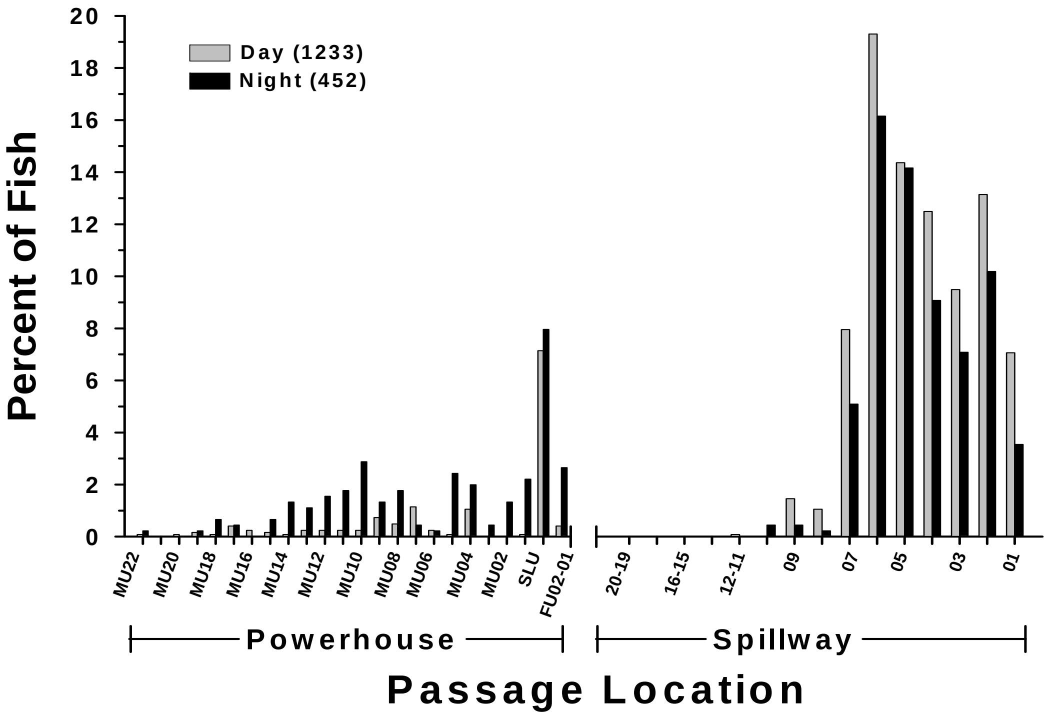


Figure 38. Radio-tagged subyearling Chinook salmon passage via the powerhouse and the spillway during 40% bulk spill discharge at The Dalles Dam, 19 June through 29 July 2004. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Passage locations based only on forebay underwater antennas and sluiceway aerial antennas. Sample sizes are in parentheses. MU = main turbine unit. SLU = sluiceway. FU = fish turbine unit.

FPE, SPE, and SLPE Relative to Approach

Subyearling Chinook salmon at the upriver entrance that approached the forebay near the south shore generally had lower FPE and SPEs and higher SLPES than fish entering the forebay farther from the dam, but we were unable to detect statistically significant differences during the day or the night (chi-square and F-tests, all $P > 0.05$, df = 2; Figures 39 through 41, Appendix U). Daytime FPE ranged from 90 to 95% among locations, whereas at night, FPE ranged from 46% for fish entering the forebay via the more southern route to 73 % for fish approaching by more northern routes (Table 12). The SPE was lower for fish entering the forebay via more southern than northern routes during both the day and the night (79 vs. 87% and 37 vs. 68%). The SLPE ranged from 8 to 11% during the day and from 5 to 8% at night.

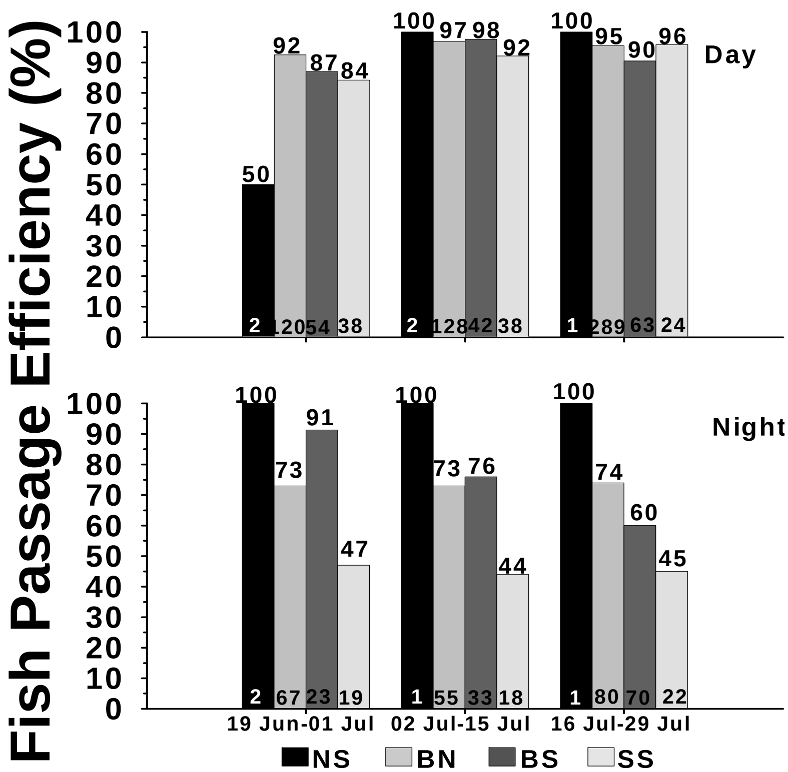


Figure 39. Diel estimates of radio-tagged subyearling Chinook salmon spill passage efficiency by upriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

Figure 40. Diel estimates of radio-tagged subyearling Chinook salmon spill passage efficiency by upriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

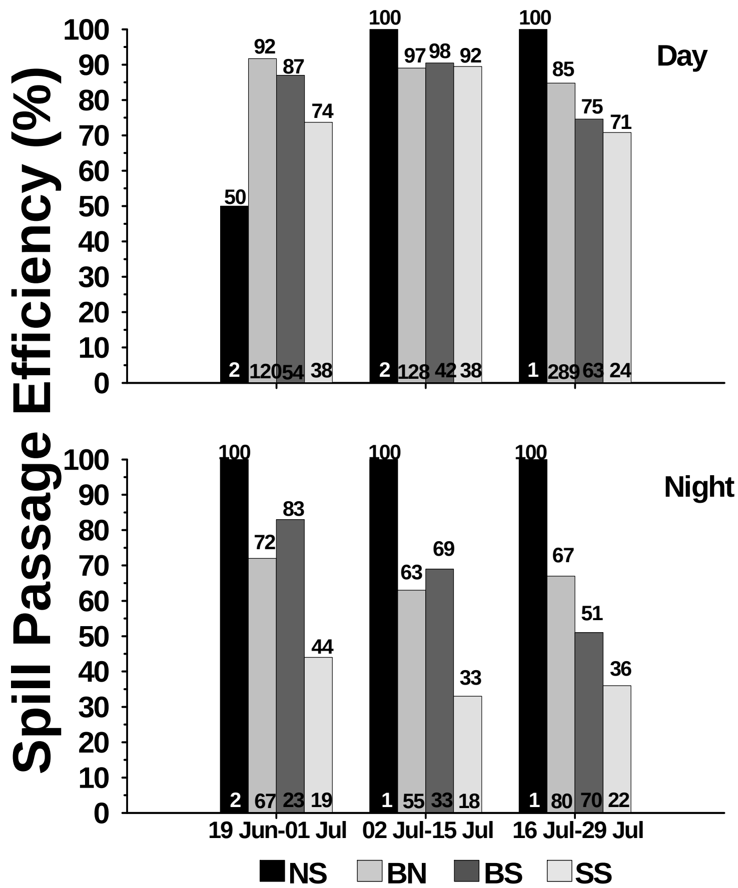


Figure 41. Diel estimates of radio-tagged subyearling Chinook salmon sluiceway passage efficiency by upriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

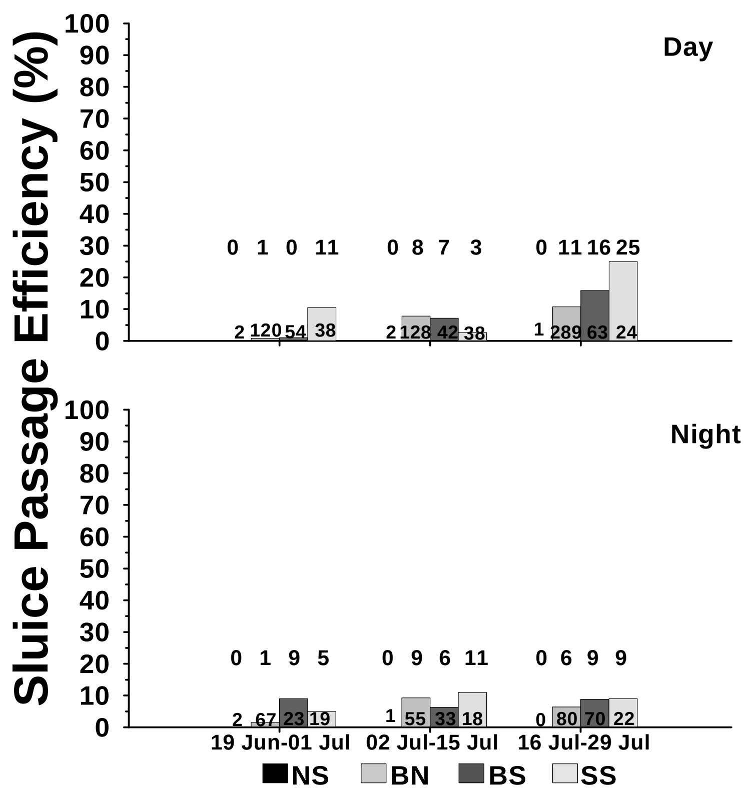


Table 12. Diel fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE) estimates (Est) of subyearling Chinook salmon detected at the upriver entrance by approach location during 40% bulk spill discharge at The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. *N* = sample sizes adjusted for detection efficiency. CI = quasi-(^{Q}) or profile-likelihood (^{B}) confidence interval estimates.

Passage efficiency	Approach location	Day Est %	Day 95% CI	Day N	Night Est %	Night 95% CI	Night N
$FPE^{Q,Q}$	BN	95.2	92.6 - 97.1	537	73.3	65.0 - 80.6	202
	BS	91.2	84.7 - 95.6	159	69.8	59.0 - 79.4	126
	SS	90.0	81.2 - 95.7	100	45.8	30.1 - 62.0	59
$SPE^{Q,Q}$	BN	87.3	82.6 - 91.2	537	67.8	59.2 - 75.7	202
	BS	83.0	72.9 - 90.7	159	61.9	50.7 - 72.3	126
	SS	79.0	65.3 - 89.3	100	37.3	22.7 - 53.7	59
$SLPE^{Q,B}$	BN	7.8	3.4 - 14.7	537	5.4	2.9 - 9.2	202
	BS	8.2	1.5 - 22.6	159	7.9	4.1 - 13.5	126
	SS	11.0	1.7 - 31.5	100	8.5	3.1 - 17.3	59

At the downriver entrance, differences in FPE and SPEs were statistically different among approach locations during the day and the night (chi-square and F-tests, all $P < 0.0005$, df = 2; Figure 42 and 43, Appendix V). During the day, FPE increased from 92% for fish approaching near the south shore to 99% for fish approaching by the more northern routes and at night FPE increased from 54 to 96% (Table 13). Similarly, SPE ranged from 80 to 94% during the day and 44 to 90% at night. Horizontal location had a significant effect on SLPE during the day, but no significant effect at night (F-tests, $P < 0.002$ and $P > 0.39$, df = 2; Figure 44). SLPE ranged from 3 to 12% during the day and 5 to 10% at night.

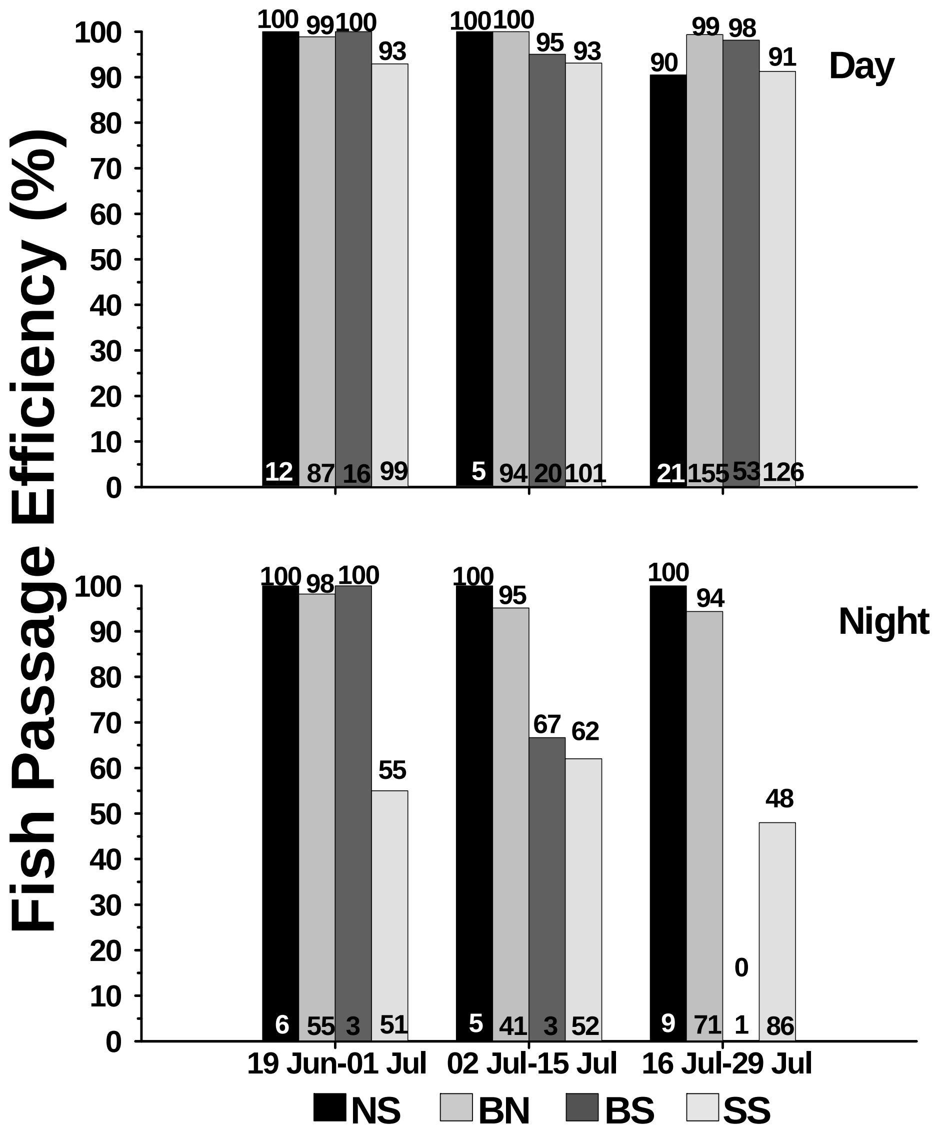


Figure 42. Diel estimates of radio-tagged subyearling Chinook salmon fish passage efficiency by downriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

Figure 43. Diel estimates of radio-tagged subyearling Chinook salmon spill passage efficiency by downriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

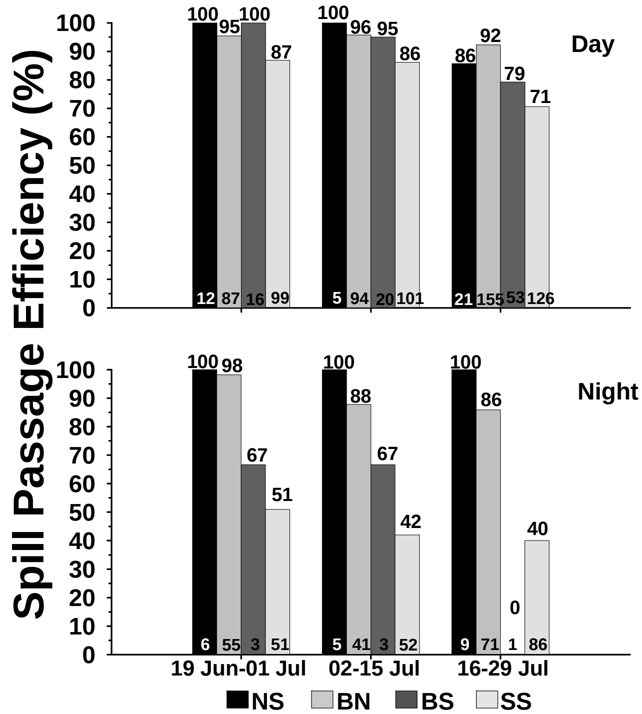


Figure 44. Diel estimates of radio-tagged subyearling Chinook salmon spill passage efficiency by downriver entrance location and seasonal period, summer 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. Day and night refer to the hours from 0530 to 2059 and 2100 to 0529. Actual percentages (above bars) and sample sizes (on bar) have been adjusted for detection efficiencies.

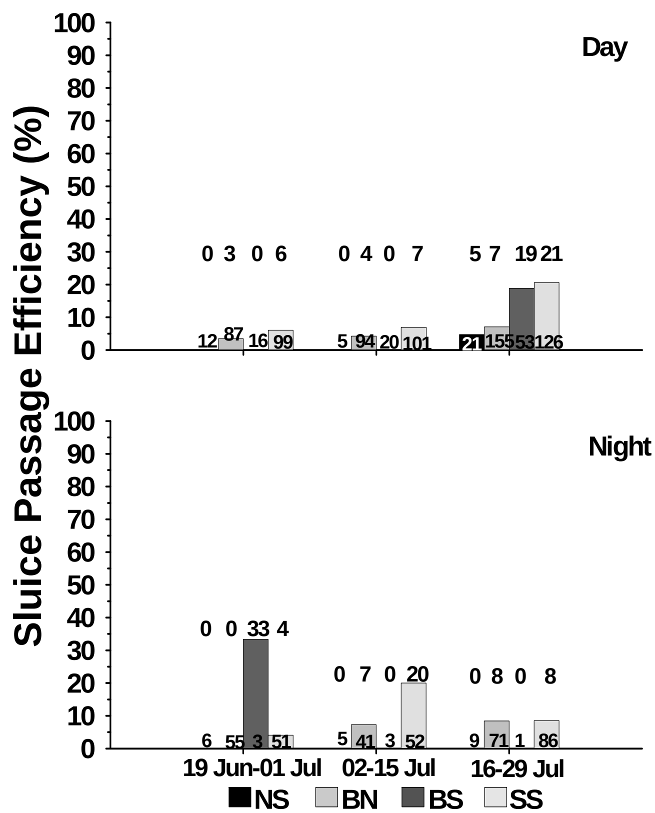


Table 13. Diel fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) estimates (Est) of subyearling Chinook salmon detected at the downriver entrance by approach location during 40% bulk spill discharge at The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. *N* = sample sizes adjusted for detection efficiencies. CI = confidence interval. Confidence intervals are profile-likelihood estimates (^{B}) or quasi-likelihood estimates (^{Q}). The NS and BS locations were not included in the night analysis due to small sample sizes (see Figure 42).

Passage	Approach	Day			Night		
efficiency	location	Est %	95% CI	*N*	Est %	95% CI	*N*
$FPE^{B,B}$	NS	94.7	84.6 - 99.1	38	-	-	-
	BN	99.4	98.2 - 99.9	336	95.8	92.1 - 98.2	167
	BS	97.7	93.2 - 99.6	89	-	-	-
	SS	92.3	89.1 - 94.9	326	53.7	46.6 - 60.8	188
$SPE^{Q,Q}$	NS	92.1	68.5 - 99.6	38	-	-	-
	BN	94.0	88.4 - 97.6	336	90.4	82.4 - 95.7	167
	BS	86.5	70.8 - 95.8	89	-	-	-
	SS	80.4	71.9 - 87.3	326	43.6	33.3 - 54.3	189
$SLPE^{Q,Q}$	NS	2.6	0.0 - 23.8	38	-	-	-
	BN	5.4	2.0 - 11.1	336	5.4	1.2 - 14.4	167
	BS	11.2	2.8 - 27.2	89	-	-	-
	SS	12.0	6.4 - 19.6	326	10.1	3.9 - 20.2	189

SLPE and FPE Relative to Sluiceway Operations

Opening two sluiceway entrances instead of just one entrance did not consistently improve SLPE or FPE (Figures 45 and 46). Overall, SLPE was 0.8% greater during the MU01 treatment than the MU18+MU01 treatment, while FPE was 1.5% less, but neither difference was statistically significant (chi-square tests, all $P > 0.37$, df = 2; Appendices W and X). The SLPE and FPE were estimated to be 4.4 and 84.9% during the MU01 treatment and 3.6 and 86.4% during the MU01+MU18 treatment (Table 14). During the MU01+MU18 treatment, 12% of the fish passing via the sluiceway entered through the MU18 entrance ($N = 3$), while 88% of fish entered through the MU01 entrance ($N = 23$).

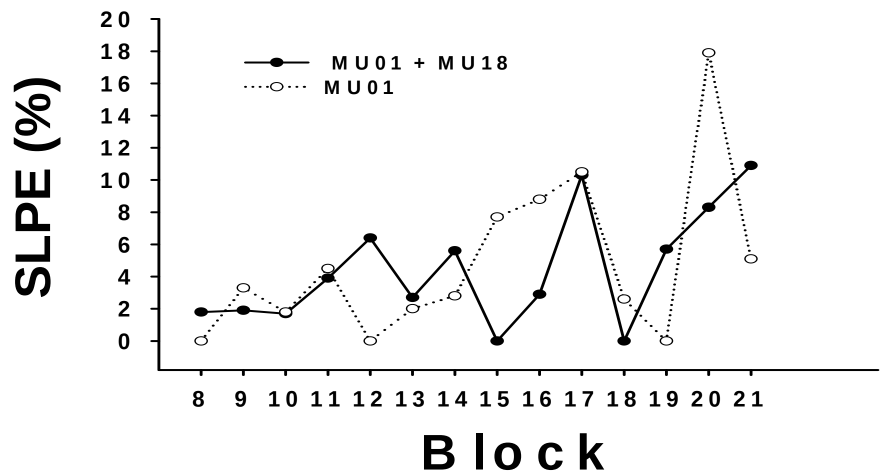


Figure 45. Sluiceway passage efficiency (SLPE) of subyearling Chinook salmon by block and sluiceway treatment at The Dalles Dam, summer 2004. MU01 + MU18 = Main turbine unit (MU) 01 and MU18 sluiceway entrances open. MU01 = MU01 sluiceway entrance open. Sample sizes are given in appendix W.

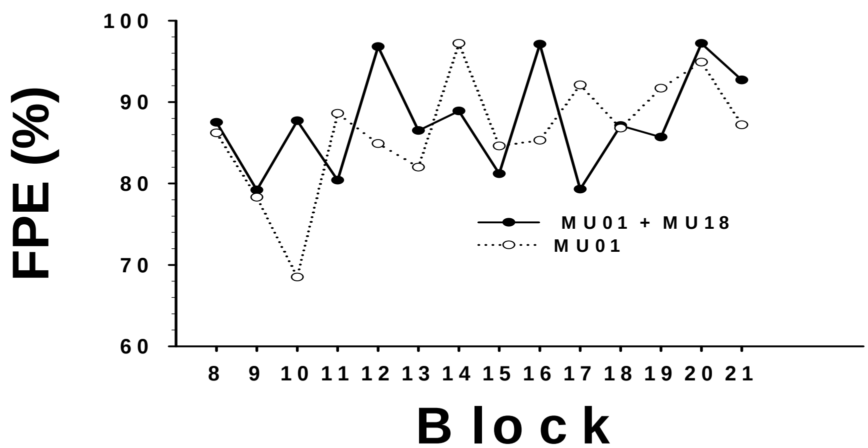


Figure 46. Fish passage efficiency (FPE) of subyearling Chinook salmon by block and sluiceway treatment at The Dalles Dam, summer 2004. MU01 + MU18 = Main turbine unit (MU) 01 and MU18 sluiceway entrances open. MU01 = MU01 sluiceway entrance open. Sample sizes are given in appendix X.

Table 14. Subyearling Chinook salmon sluiceway (SLPE) and fish passage efficiency (FPE) point estimates (Est) during two sluiceway operation scenarios at The Dalles Dam, 19 June through 17 July 2004. MU01 = MU01 entrance open. MU01+MU18 = MU01 and MU18 sluiceway entrances open. QRCI = quasi-likelihood confidence interval estimates. *N* = sample size.

Passage	MU01 Treatment			MU01+MU18 Treatment		
efficiency	Est %	95% QRCI	*N*	Est %	95% QRCI	*N*
SLPE	4.4	2.5 - 7.0	569	3.6	1.9 - 6.2	521
FPE	84.9	80.4 - 88.7	569	86.4	81.9 - 90.2	521

During the MU18+MU01 treatment, most subyearling Chinook salmon detected within 10 m of the powerhouse first approached the dam downstream of the MU18 sluiceway entrance (Figure 47). About 60% of these fish were first detected from MU17 to MU06, 18% were first detected at MU05 to MU01, and 9% were first detected at FU02 to FU01, while 13% were first detected from MU22 down to the MU18 sluice entrance (Table 15). Some of these fish entered the turbines near where they first approached or further downstream, but most passed through the spillway or the sluiceway entrance at MU01. Depending on the area of the powerhouse where the fish were first detected, 51 to 80% eventually passed through the spillway and 10 to 37% passed through the turbines (Table 15). About 24% of the fish first detected from MU05 to MU01 passed via the sluiceway entrance at MU01, but only 3 to 10% of the fish detected at the other powerhouse areas entered this entrance. Thus, the fish entering the MU01 sluice entrance were an aggregate of individuals comprised largely of fish first detected from MU05 to FU01 (60%) and to a smaller degree fish first detected from MU22 to MU06 (40%).

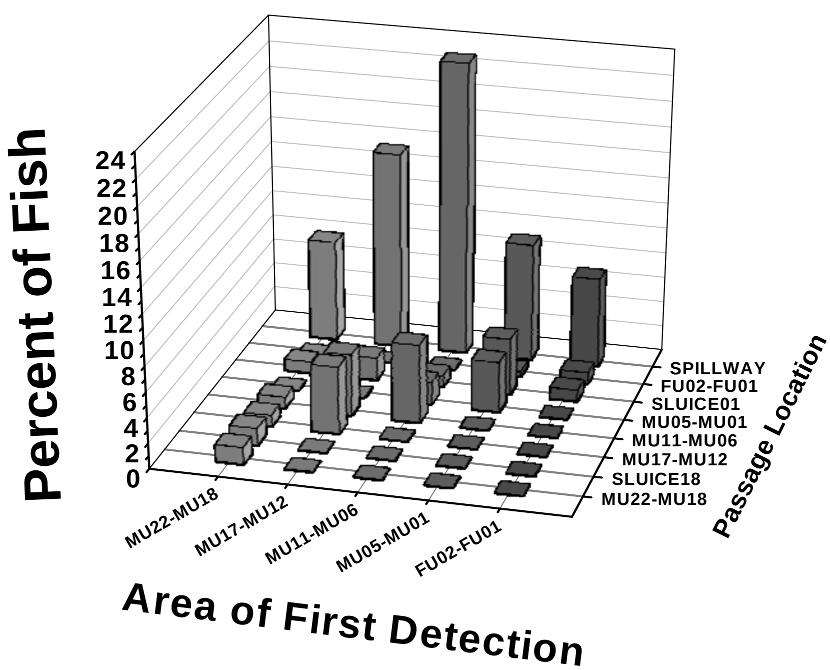


Figure 47. Percentage subyearling Chinook salmon first detected at various powerhouse main turbine unit (MU) areas that passed via the same turbine areas, main unit (MU) 18 sluiceway entrance, MU01 sluiceway entrance, or spillway when both the MU18 and MU01 sluiceway entrances were open at The Dalles Dam, 19 June through 17 July 2004. All 40 bars sum to 100%. Total sample size equals 225.

All fish entering the MU18 sluice entrance were first detected near the powerhouse at MU18 and represented 10% of all the fish first detected from MU22 to MU18. Fish did not generally pass upstream of where they were first detected. Overall, 63% of the fish first approaching near the dam at the powerhouse passed via the spillway, 9% passed via the sluiceway entrance at MU01, 27% passed via the turbines, and 1% passed via the sluiceway entrance at MU18. Radio-tagged fish first detected at the powerhouse during the MU01 treatment exhibited similar trends.

Table 15. Percentage of subyearling Chinook salmon passage via various powerhouse main turbine units (MU) areas, sluiceway entrance at MU18 or MU01, fish turbine units (FU) 1 and 2, or the spillway by area of first near-dam detection (<10 m) at The Dalles Dam, 19 June through 17 July 2004. MU18+MU01 treatment = MU18 and MU01 sluiceway entrances open. MU01 treatment = MU01 treatment open. Sample size: MU18+MU01 = 225, MU01 = 222.

Passage Location	MU18+MU01 Treatment: Area of First Near-Dam Detection					Percent of Total Passage
	MU22-18	MU17-12	MU11-06	MU05-01	FU02-01	
MU22-18	10.0	0.0	0.0	0.0	0.0	1.3
Sluice-18	10.0	0.0	0.0	0.0	0.0	1.3
MU17-12	6.7	19.4	0.0	0.0	0.0	6.2
MU11-06	6.7	17.7	19.4	0.0	0.0	12.1
MU05-01	0.0	0.0	5.6	22.0	0.0	5.8
Sluice-01	6.6	6.5	2.8	24.4	10.0	8.9
FU02-01	0.0	0.0	0.0	2.4	10.0	1.3
Spillway	60.0	56.4	72.2	51.2	80.0	63.1
Percent Total First Detections	13.3	27.6	32.0	18.2	8.9	

Passage Location	MU01 Treatment: Area of First Near-Dam Detection					Percent of Total Passage
	MU22-18	MU17-12	MU11-06	MU05-01	FU02-01	
MU22-18		0.0	0.0	0.0	0.0	1.8
Sluice-18		0.0	0.0	0.0	0.0	0.0
MU17-12		18.5	0.0	0.0	0.0	9.5
MU11-06		13.9	16.7	0.0	0.0	8.6
MU05-01		1.5	3.3	16.7	0.0	4.5
Sluice-01		9.2	5.0	23.8	12.0	10.8
FU02-01		0.0	1.7	4.7	16.0	3.1
Spillway		56.9	73.3	54.8	72.0	61.7
Percent Total First Detections	13.5	29.3	27.0	18.9	11.3	

Total Project FPE, SPE, and SLPE

Radio-tagged subyearling Chinook salmon FPE and SPE were consistently greater during the day than the night period among days, but there was no clear diel trend in SLPE (Figure 48). These day and night differences in FPE and SPE were statistically significant, but SLPE did not differ between diel periods (F-tests, all $P < 0.0001$ and $P > 0.90$, df = 1; Appendices Y through AA). Point estimates of FPE during day and night were 93 and 64%, estimates of SPE were 86 and 58%, and SLPE was estimated to be 7 and 6% (Table 16). Overall (day and night pooled across season), estimates of FPE, SPE, and SLPE were 84, 78, and 7%, respectively. Hourly FPE estimates for summer indicate

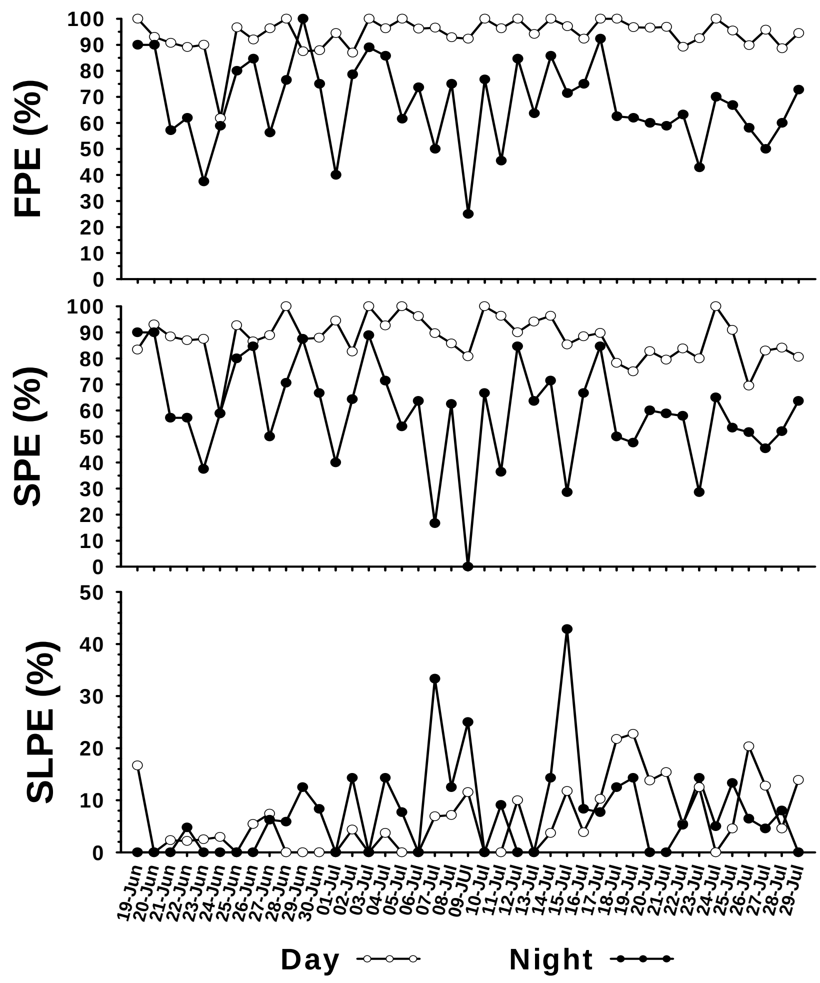


Figure 48. Daily diel estimates of radio-tagged subyearling Chinook salmon passage efficiency (FPE), spill passage efficiency (SPE), and sluiceway passage efficiency (SLPE), 19 June through 29 July 2004. Efficiency estimates are expressed as a percent. Day and night refer to the hours 0530 to 2059 and 2100 to 0529. Sample sizes are given in Appendices Y through AA.

that turbine passage was relatively higher (23 to 53%) between 2200 and 0459 hours than between 0500 and 2159 hours (2 to 16%; Figure 49). Subyearling Chinook salmon spill effectiveness was 2.2 during the day, 1.5 at night, and 2.0 overall.

Table 16. Diel and overall fish-, spill-, and sluiceway passage efficiency (FPE, SPE, and SLPE) estimates of subyearling Chinook salmon detected at The Dalles Dam during 40% bulk spill discharge, 19 June through 29 July 2004. An asterisk (*) indicates significant differences between day and night periods. QRCI = quasi-likelihood confidence interval. *N* = sample size adjusted for detection efficiencies.

Diel period	Passage efficiency	Estimates (%)	95% QRCI	*N*
Day	FPE*	93.1	91.2 - 94.8	1303
	SPE*	86.3	83.6 - 88.8	1303
	SLPE	6.8	5.1 - 8.8	1303
Night	FPE	64.5	59.2 - 69.6	558
	SPE	58.1	52.2 - 63.8	558
	SLPE	6.5	4.0 - 9.6	558
Overall	FPE	84.5	80.8 - 87.8	1861
	SPE	77.9	73.9 - 81.5	1861
	SLPE	6.7	5.2 - 8.3	1861

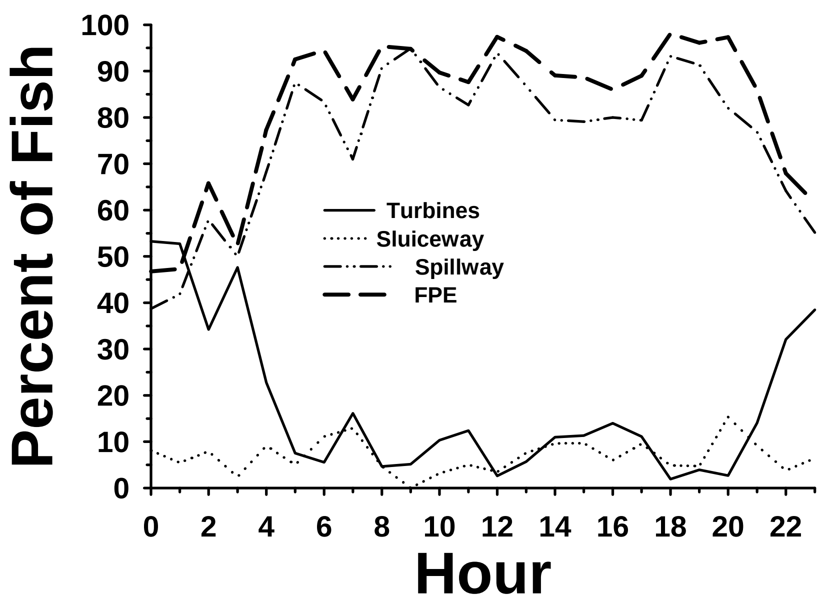


Figure 49. Percentage of subyearling Chinook salmon passing through The Dalles Dam turbines, sluiceway, and spillway and fish passage efficiency (FPE) by hour, 19 June through 29 July 2004. *N* = 1848.

Discussion

This study is part of a series of recent investigations at TDA designed to determine the feasibility of various surface bypass strategies for enhancing juvenile salmonid non-turbine passage and fish survival. In 2001 and 2002, these studies focused on the potential benefits of a sluiceway guidance improvement device for turbine passage reduction (Hausmann et al. 2004, Johnson et al. 2003). In 2003, the focal point of study at TDA shifted to other surface bypass devices such as a forebay guidance curtain (Adams and Rondorf 1988). In particular, the USGS was asked to determine the horizontal distribution (north to south) of yearling and subyearling Chinook salmon as they entered the forebay and the effect of forebay entrance location on fish passage behavior. During the current study, we determined total project FPE, SPE, and SLPE of yearling and subyearling Chinook salmon during 40% bulk spill with respect to the new spill training wall; determined the horizontal distribution of radio-tagged fish entering the forebay and the effect of entrance location on fish passage behavior, and; compared the effect of two sluiceway operation scenarios on total project SLPE and FPE.

Passage Relative to Approach

Our results indicate that turbine passage could be reduced if yearling and subyearling Chinook salmon could be redirected from southern to more northern approach routes. About 28% of the yearling Chinook salmon and 43% of the subyearling Chinook salmon approached the downriver entrance at the southernmost entrance location. During spring and summer, turbine entrainment of radio-tagged fish was generally significantly greater for those fish entering the forebay from the south than for fish entering from the north, with the greatest differences at night. During the day, at the downriver entrance, yearling Chinook salmon FPE differed by 3% between fish approaching from the north and fish approaching from the south, but at night the difference was 27%. Subyearling Chinook salmon FPE relative to their north and south horizontal locations at the downriver forebay entrance differed by 7% during the day and by 42% at night. These data are similar to those in 2003 at night, when yearling and subyearling Chinook salmon

FPE relative to their north and south horizontal locations at the downriver entrance differed by 26 and 34% (Hansel et al. 2004).

The 2004 and 2003 results are supported by ultrasonic three-dimensional (3-D) behavior studies at TDA in 2004 (Cash et al. 2005). The 3-D research indicates that juvenile salmonids entering the forebay tend to converge in a relatively deepwater area at the east end of the powerhouse. Fish then predominantly move either from an area near the downriver barge south area towards and along the powerhouse, or from the downriver barge north area along a more direct mid-river approach to the spillway.

The amount of increase in overall FPE achieved by guiding migrants to a more northerly approach depends on the percentage of fish that can be guided and the diel distribution of the time of arrival of run-of-the-river fish. Using a simple model that includes length, depth, location, and angle parameters for a potential behavioral guidance structure, Cash et al. (2005) estimated that yearling Chinook salmon SPE could have been increased by 6 percentage points in 2004.

Sluiceway Operation Tests

Opening two sluiceway entrances (one at MU18 and another at MU01) instead of one entrance (MU01), as has been the standard practice at TDA had little effect on sluiceway passage. Overall differences in SLPE and FPE between the MU18+MU01 and the MU01 only treatments were small (0.8 to 2.2%) and not statistically significant. The lack of a significant increase in SLPE, as one would expect, when two sluiceway entrances were open compared to one entrance, was due to only 3% of the radio-tagged yearling Chinook salmon and 12% of the subyearling Chinook salmon entering the sluiceway by passing through MU18 entrance during the MU18+MU01 treatment. Concurrently, a similar or lower proportion of the total number of fish passing the dam entered the sluiceway through the entrance at MU01 during the MU18+MU01 treatment than the MU01 treatment.

Lower than anticipated numbers of radio-tagged fish entering the sluiceway when two entrances are open may be due to a combination of two factors. The first being changes in entrance flows and water velocities and the second, entrance location relative to fish approach to the powerhouse. Although total flow is increased when two entrances are open, the individual flows into MU01 and MU18 are 15 and 42% lower compared to the MU01 only flow. Similarly, average water velocities are 6 and 4 ft/s over the weirs at the sluice entrances at MU01 and MU18 when both are operated, compared to about 7 ft/s when MU01 is operated alone. Reduced entrance flows and velocities may attract fewer fish and reduce entrance efficiencies.

A second factor that also may have potentially reduced the observed differences between sluiceway treatments was the location of the second sluiceway entrance relative to fish movements near the powerhouse. Our results indicate that only 7% of the yearling Chinook salmon and 13% of the subyearling Chinook salmon detected within 10 m of the powerhouse were first detected at MU22 to MU18 and that 10% of both groups of fish entered the sluiceway entrance at MU18. Most fish were first detected near the powerhouse from MU17 to MU01, and yearling and subyearling Chinook salmon entering the sluiceway entrance at MU01 represented an aggregation of fish that were first detected as far upstream as the easternmost end of the powerhouse.

Concurrent fixed-location hydroacoustic evaluation of run-of-the-river fish and ultrasonic 3-D evaluation of tagged fish entering the sluiceway at TDA in 2004 showed similar trends as the radio-telemetry data, particularly in spring (Cash et al. 2005, Johnson et al. 2005a). However, during summer, the hydroacoustic research showed a substantially greater proportion of fish entering the sluiceway through the MU18 sluiceway entrance than either the radio- or ultrasonic-tagged fish (Johnson et al. 2005). During spring, the radio-telemetry study indicated that 1% of the fish entered via the entrance at MU18 and the fixed-hydroacoustic study indicated 10% of the fish entered via this route. During the summer, the same studies indicated that 6 and 40% of the fish entered the sluiceway through the MU18 entrance. In spite of these localized differences, radio-telemetry and hydroacoustic estimates of SLPE relative to total project and total powerhouse passage were similar.

It is not clear why the techniques differed in the estimate of the proportion of fish entering the sluiceway through the MU18 entrance, but Johnson et al. (2005a) suggest that it may be due to the differences in species composition and size distribution of the sampled population, sample sizes, sample locations, and time periods sampled. Although all these factors may potentially play a role in the differences observed, some may be more important than others. During summer, when the greatest differences in the two methods occurred, species composition may have had very little effect since 89% of the summer migrants were comprised of subyearling Chinook salmon. Summer radio-telemetry sample sizes during the sluiceway study were relatively small compared to spring, the radio-tagged subyearling Chinook salmon were bigger than run-of-the-river fish, the period of study was 7 blocks shorter in duration than the hydroacoustic study, and the location where fish were determined to have entered an entrance differed between the two studies. During the hydroacoustic study, sluiceway passage was determined by fish detected near the turbine pier noses adjacent to the forebay, whereas radio-tagged fish passing the sluiceway were detected inside the sluiceway channel itself. Each of these factors could be a source of the localized differences between the radio-telemetry and hydroacoustic studies. In addition, the methods differ inherently in how the total numbers of fish passing via each passage route are derived.

Johnson et al. (2005a) suggest repeating the current study or conducting a similar study with a new east-end entrance that may provide benefits greater than those observed at MU18. Our data support such a recommendation, but indicate the optimal location for the east entrance would be one that takes greatest advantage of the cumulative number of upriver fish moving along the powerhouse, without passing a large proportion of the fish that would have entered the MU01 entrance anyway. Such a location is probably half way between the westernmost operational turbines that are consistently loaded throughout the season and the easternmost turbines that are consistently loaded. For example, during the 2004 study, an east entrance at MU11 would have potentially passed the greatest numbers of fish moving downriver that first approached somewhere upriver and later passed from MU17 to FU01 and at the same time would have passed the lowest proportion of fish that would otherwise probably have entered the MU01 sluiceway entrance.

Another potential scenario to consider might be to have sluiceway entrances at 3 locations, but open only 2 sluice gates per entrance instead of the 3 sluice gates per entrance being operated currently. As long as this scenario did not detrimentally affect entrance hydraulics so that individual entrance efficiency was greatly reduced, this configuration could potentially provide even greater benefits by increasing the number of sluiceway entrances and decreasing the distance between them. Based on studies of a prototype surface flow bypass at Lower Granite Dam on the Snake River in Washington, Johnson et al. (2005b) suggested that new surface bypass devices should incorporate: 1) an extensive flow net using a high surface flow bypass discharge when possible (> 7% of total project discharge); 2) a gradual increase in water velocity with increasing proximity to the surface bypass (acceleration < 1 m/s per meter), and; 3) water velocities > 3 m/s at the bypass entrance to increase fish entrainment.

Total Project FPE, SPE, and SLPE

Total project FPE for all radio-tagged fish detected in the forebay indicated greater turbine entrainment at night than during the day. At night, 15% more of the yearling Chinook salmon and 29% more of the subyearling Chinook salmon passed via the turbines than during the day. In 2003, 17% more yearling Chinook salmon and 24% more subyearling Chinook salmon passed via the turbines at night than during the day (Hansel et al. 2004). These differences are most likely due to changes in diel fish behavior that may increase the probability that a fish will sound or more readily follow the bulk flow into turbine intakes at night, or diel changes in dam operations such as total project discharge.

Total project FPE, SPE, and SLPE estimates of this study and the concurrent hydroacoustic study conducted by Johnson et al. (2005a) were similar. We estimated yearling Chinook salmon total project FPE, SPE, and SLPE during spring to be 93, 84, and 9%, while Johnson et al. (2005a) estimated the same efficiencies for all spring migrants to be 91, 84, and 7%. During summer, we estimated FPE, SPE, and SLPE to be 84, 78, and 7%, while the hydroacoustic study estimated these efficiencies to be 82, 78, and 4%. Yearling and subyearling Chinook salmon SPE estimates were similar to those in 2003, but SLPE estimates were lower. The net result was higher FPE estimates during the spring and lower estimates during summer than in 2003. In 2003, yearling and subyearling Chinook salmon FPE were estimated to be 88 and 89%, SPE was estimated to be 70 and 77%, and SLPE was estimated to be 17 and 11% (Hansel et al. 2004). These differences may have been due to the initiation of the bulk spill discharge pattern through bays 1 through 6 in 2004 or other potential differences in dam operations between the two years. In 2004, once the sluice operations test was over, most turbine discharge occurred from MU01 to MU12 and SLPE increased.

Spillway Passage Relative to the Spill Training Wall

Although spill was equally distributed across spill bays 1 through 6 during spring and summer, our data indicates that most fish passed closest to the training wall at spill bay 6 and fewest fish passed through spill bay 1. Increased passage at spill bay 6 and 5 and the relatively high effectiveness of a small volume of spill at bay 7 was probably a function of fish approach to the spillway. Forty-two percent of the yearling Chinook salmon and 37% of the subyearling Chinook salmon were first detected within 10 m of the spillway between spill bays 6 and 23. These findings are consistent with both hydroacoustic and ultrasonic-tag studies (Cash et al. 2005, Johnson et al. 2005a). Fish monitored during the ultrasonic study that traveled along a route near the powerhouse moved towards the open spill bays once they reached the non-overflow wall, while other fish took a more direct approach to the spillway, putting the greatest proportion of fish upstream of bays 5, 6, and 7. This is of potential concern since other studies have indicated fish passing through these bays may experience greater mortalities than those passing through bays 1 through 4 (Couihan et al. 2006b; Heisey et al. 2004). Spill strategies favoring passage through the more northern (i.e., lower numbered) spill bays may increase spillway survival.

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Appendices

Appendix A. Sluiceway operations test study design at The Dalles Dam, spring and summer 2004. MU01 = MU01 sluiceway entrance open. MU18 = MU18 entrance open.

Study Block	Study Day	Date	Day of Week	Sluice Treatment	Study Block	Study Day	Date	Day of Week	Sluice Treatment
Spring Study									
1	1	19-Apr	Mon	MU01	14	27	15-May	Sat	MU01, MU18
1	2	20-Apr	Tue	MU01, MU18	14	28	16-May	Sun	MU01
2	3	21-Apr	Wed	MU01, MU18	15	29	17-May	Mon	MU01
2	4	22-Apr	Thur	MU01	15	30	18-May	Tue	MU01, MU18
3	5	23-Apr	Fri	MU01, MU18	16	31	19-May	Wed	MU01, MU18
3	6	24-Apr	Sat	MU01	16	32	20-May	Thur	MU01
4	7	25-Apr	Sun	MU01, MU18	17	33	21-May	Fri	MU01
4	8	26-Apr	Mon	MU01	17	34	22-May	Sat	MU01, MU18
5	9	27-Apr	Tue	MU01	18	35	23-May	Sun	MU01, MU18
5	10	28-Apr	Wed	MU01, MU18	18	36	24-May	Mon	MU01
6	11	29-Apr	Thur	MU01, MU18	19	37	25-May	Tue	MU01, MU18
6	12	30-Apr	Fri	MU01	19	38	26-May	Wed	MU01
7	13	01-May	Sat	MU01	20	39	27-May	Thur	MU01, MU18
7	14	02-May	Sun	MU01, MU18	20	40	28-May	Fri	MU01
8	15	03-May	Mon	MU01	21	41	29-May	Sat	MU01
8	16	04-May	Tue	MU01, MU18	21	42	30-May	Sun	MU01, MU18
9	17	05-May	Wed	MU01	22	43	31-May	Mon	MU01
9	18	06-May	Thur	MU01, MU18	22	44	01-Jun	Tue	MU01, MU18
10	19	07-May	Fri	MU01	23	45	02-Jun	Wed	MU01, MU18
10	20	08-May	Sat	MU01, MU18	23	46	03-Jun	Thur	MU01
11	21	09-May	Sun	MU01, MU18	24	47	04-Jun	Fri	MU01
11	22	10-May	Mon	MU01	24	48	05-Jun	Sat	MU01, MU18
12	23	11-May	Tue	MU01, MU18					
12	24	12-May	Wed	MU01					
13	25	13-May	Thur	MU01, MU18					
13	26	14-May	Fri	MU01					
Summer Study									
1	1	06-Jun	Sun	MU01	12	23	28-Jun	Mon	MU01, MU18
1	2	07-Jun	Mon	MU01, MU18	12	24	29-Jun	Tue	MU01
2	3	08-Jun	Tue	MU01, MU18	13	25	30-Jun	Wed	MU01, MU18
2	4	09-Jun	Wed	MU01	13	26	01-Jul	Thur	MU01
3	5	10-Jun	Thur	MU01, MU18	14	27	02-Jul	Fri	MU01, MU18
3	6	11-Jun	Fri	MU01	14	28	03-Jul	Sat	MU01
4	7	12-Jun	Sat	MU01, MU18	15	29	04-Jul	Sun	MU01
4	8	13-Jun	Sun	MU01	15	30	05-Jul	Mon	MU01, MU18
5	9	14-Jun	Mon	MU01	16	31	06-Jul	Tue	MU01, MU18
5	10	15-Jun	Tue	MU01, MU18	16	32	07-Jul	Wed	MU01

Appendix A. Continued.

Study Block	Study Day	Date	Day of Week	Sluice Treatment	Study Block	Study Day	Date	Day of Week	Sluice Treatment
6	11	16-Jun	Wed	MU01, MU18	17	33	08-Jul	Thur	MU01
6	12	17-Jun	Thur	MU01	17	34	09-Jul	Fri	MU01, MU18
7	13	18-Jun	Fri	MU01	18	35	10-Jul	Sat	MU01, MU18
7	14	19-Jun	Sat	MU01, MU18	18	36	11-Jul	Sun	MU01
8	15	20-Jun	Sun	MU01	19	37	12-Jul	Mon	MU01, MU18
8	16	21-Jun	Mon	MU01, MU18	19	38	13-Jul	Tue	MU01
9	17	22-Jun	Tue	MU01	20	39	14-Jul	Wed	MU01, MU18
9	18	23-Jun	Wed	MU01, MU18	20	40	15-Jul	Thur	MU01
10	19	24-Jun	Thur	MU01	21	41	16-Jul	Fri	MU01
10	20	25-Jun	Fri	MU01, MU18	21	42	17-Jul	Sat	MU01, MU18
11	21	26-Jun	Sat	MU01, MU18					
11	22	27-Jun	Sun	MU01					

Appendix B. Release date, release time (hours), sample size (N), mean, standard deviation (SD), and range of fork lengths (mm) and weights (g) of yearling Chinook salmon released from the John Day Dam tailrace during spring 2004.

Release	Release		Fork length (mm)			Weight (g)		
Date	Hour	N	Mean	SD	Range	Mean	SD	Range
042704	0700	30	149	9.6	132 - 180	31.7	6.2	24.2 - 57.4
042704	1900	34	151	10.1	135 - 175	35.0	7.9	24.9 - 56.5
042804	0700	34	150	9.6	134 - 172	34.0	7.1	22.8 - 52.4
042804	1900	34	150	8.4	135 - 172	34.0	6.0	23.8 - 48.1
042904	0700	35	153	9.3	137 - 188	34.7	7.2	25.1 - 66.6
042904	1900	38	158	11.0	140 - 188	38.8	8.7	25.9 - 66.8
043004	0700	34	145	9.8	127 - 179	37.6	8.1	23.6 - 70.3
043004	1900	36	151	10.0	133 - 176	35.7	7.9	22.3 - 54.5
050104	0700	36	142	9.7	124 - 178	34.6	6.7	25.2 - 60.7
050104	1900	36	152	8.8	138 - 179	35.8	6.8	25.5 - 59.9
050204	0700	35	152	11.5	135 - 194	35.6	8.5	25.7 - 69.5
050204	1900	38	154	9.4	135 - 180	35.2	6.6	24.9 - 51.9
050304	0700	36	154	10.6	140 - 183	36.4	8.0	26.3 - 60.7
050304	1900	34	153	10.7	140 - 182	36.1	7.5	26.6 - 56.6
050404	0700	35	150	12.8	131 - 180	33.8	8.3	23.9 - 55.9
050404	1900	35	152	11.9	131 - 188	35.8	8.7	25.0 - 66.8
050504	0700	35	147	8.6	134 - 169	31.9	6.2	22.4 - 47.9
050504	1900	34	148	9.6	134 - 175	32.7	7.0	22.3 - 54.3
050604	0700	35	145	8.9	132 - 172	29.2	6.5	21.5 - 50.2
050604	1900	34	152	14.8	130 - 185	35.8	11.4	21.5 - 62.7
050704	0700	31	155	11.6	136 - 185	36.6	8.3	25.8 - 57.4
050704	1900	35	155	11.7	139 - 189	37.3	8.7	28.8 - 62.0
050804	0700	35	153	12.5	134 - 186	34.9	8.8	24.3 - 54.7
050804	1900	35	151	13.9	132 - 186	39.5	11.5	25.9 - 69.6
050904	0700	35	155	14.2	135 - 191	37.1	10.4	23.5 - 62.1
050904	1900	35	148	13.6	130 - 186	36.6	9.2	25.2 - 64.0
051004	0700	35	154	16.4	134 - 205	36.4	12.9	21.5 - 82.9
051004	1900	36	157	12.8	135 - 189	39.7	9.7	25.1 - 68.3
051104	0700	34	152	15.1	132 - 194	35.0	11.4	22.3 - 68.9
051104	1900	36	162	18.1	134 - 202	42.9	14.6	24.4 - 80.6
051204	0700	37	155	16.4	138 - 190	35.8	11.1	25.3 - 68.8
051204	1900	36	158	16.4	134 - 204	38.6	12.8	24.2 - 86.9
051304	0700	35	163	16.0	135 - 193	41.7	12.5	22.4 - 66.7
051304	1900	36	165	18.2	137 - 204	45.7	15.2	23.5 - 81.0
051404	0700	35	162	18.6	139 - 200	43.2	14.8	24.4 - 77.9
051404	1900	36	158	15.1	135 - 185	38.6	11.2	21.7 - 59.7
051504	0700	33	167	18.8	136 - 230	45.1	18.7	22.3-124.6
051504	1900	37	162	16.5	135 - 196	41.9	13.0	22.4 - 74.2
051604	0700	36	166	18.9	137 - 200	44.8	15.2	23.4 - 78.7
051604	1900	34	164	20.5	135 - 210	44.0	16.4	22.5 - 87.9

Appendix B. Continued.

Date	Release hour	N	Fork length (mm) Mean	SD	Range	Weight (g) Mean	SD	Range
051704	0700	35	159	15.1	138 – 194	39.7	12.0	23.6 – 70.4
051704	1900	35	162	15.3	138 – 196	41.5	12.6	24.3 – 77.0
051804	0700	35	168	17.2	137 – 206	47.2	14.9	22.9 – 87.9
051804	1900	36	162	13.6	137 – 185	40.6	9.6	25.5 – 60.6
051904	0700	35	162	17.7	133 – 197	42.0	13.9	24.6 – 76.1
051904	1900	33	163	14.7	133 – 189	42.7	12.0	24.2 – 72.6
052004	0700	34	166	16.6	137 – 192	43.5	12.0	22.8 – 64.1
052004	1900	35	156	14.6	133 – 193	36.1	10.8	21.9 – 66.2
052104	0700	35	157	16.6	134 – 191	37.5	12.2	21.8 – 65.0
052104	1900	35	162	17.4	136 – 216	41.3	15.4	21.9 – 93.4
052204	0700	35	155	17.3	134 – 194	35.3	12.6	21.6 – 67.9
052204	1900	33	168	14.6	139 – 200	44.5	12.5	23.6 – 80.4
052304	0700	35	162	18.5	133 – 220	42.9	15.5	22.5 – 98.5
052304	1900	33	158	12.6	132 – 186	35.9	9.1	22.7 – 59.9
052404	0700	34	162	16.5	134 – 205	40.8	13.8	21.9 – 82.8
052404	1900	34	162	16.0	136 – 193	41.0	13.0	23.8 – 66.1
052504	0700	34	170	18.7	137 – 222	47.5	17.8	24.7-112.7
052504	1900	34	160	18.0	134 – 200	39.9	14.2	22.6 – 76.7
052604	0700	34	158	16.3	132 – 208	38.9	12.9	22.9 – 86.9
052604	1900	35	167	17.9	139 – 201	47.0	15.3	23.9 – 86.4
052704	0700	35	172	21.6	135 – 212	51.0	19.9	23.6 – 91.3
052704	1900	35	170	19.3	133 – 210	48.7	17.8	22.8 – 94.2
052804	0700	36	167	18.1	134 - 204	47.0	16.0	23.4 - 86.2
052804	1900	35	167	18.0	145 - 205	46.1	16.4	28.2 - 82.1
Overall		2230	158	16.2	124 - 230	39.2	12.7	21.5-124.6

Appendix C. Number of radio-tagged yearling Chinook salmon passing via the powerhouse, sluiceway, and spillway by diel period and date at The Dalles Dam during 40% bulk spill, spring 2004.

Date	Diel	Powerhouse	Sluiceway	Spillway
04/28/04	Day	2	3	41
04/28/04	Night	1	2	7
04/29/04	Day	0	0	41
04/29/04	Night	3	3	14
04/30/04	Day	1	3	55
04/30/04	Night	1	3	7
05/01/04	Day	4	5	48
05/01/04	Night	2	3	11
05/02/04	Day	2	1	48
05/02/04	Night	0	2	10
05/03/04	Day	3	2	51
05/03/04	Night	0	3	20
05/04/04	Day	1	3	47
05/04/04	Night	2	6	16
05/05/04	Day	2	7	30
05/05/04	Night	6	6	14
05/06/04	Day	1	4	33
05/06/04	Night	7	6	20
05/07/04	Day	0	2	32
05/07/04	Night	4	2	16
05/08/04	Day	3	1	33
05/08/04	Night	3	3	20
05/09/04	Day	2	0	35
05/09/04	Night	7	2	17
05/10/04	Day	2	1	38
05/10/04	Night	9	2	15
05/11/04	Day	3	1	50
05/11/04	Night	3	3	13
05/12/04	Day	1	3	43
05/12/04	Night	5	3	15
05/13/04	Day	1	5	36
05/13/04	Night	3	2	21
05/14/04	Day	2	2	50
05/14/04	Night	2	4	19
05/15/04	Day	2	3	51
05/15/04	Night	1	2	7
05/16/04	Day	1	2	52
05/16/04	Night	2	1	8
05/17/04	Day	0	0	44
05/17/04	Night	4	4	16
05/18/04	Day	0	1	49
05/18/04	Night	0	3	12

Appendix C. Continued.

Date	Diel	Powerhouse	Sluiceway	Spillway
05/19/04	Day	2	3	46
05/19/04	Night	1	2	10
05/20/04	Day	2	2	46
05/20/04	Night	1	2	11
05/21/04	Day	0	4	46
05/21/04	Night	1	5	6
05/22/04	Day	0	1	44
05/22/04	Night	3	2	10
05/23/04	Day	2	6	25
05/23/04	Night	5	3	18
05/24/04	Day	0	7	40
05/24/04	Night	10	0	14
05/25/04	Day	0	3	48
05/25/04	Night	6	1	7
05/26/04	Day	1	4	45
05/26/04	Night	3	1	7
05/27/04	Day	2	9	49
05/27/04	Night	2	1	6
05/28/04	Day	1	4	52
05/28/04	Night	1	1	9
05/29/04	Day	0	5	28
05/29/04	Night	1	1	0

Appendix D. Percentages of time turbines (T) 1 through 21 were operating during the day by date at The Dalles Dam, spring 2004. Fish turbine units 1 and 2 operated throughout the study. Darker colors indicate higher percentage. Day refers to 0530 to 2059 hours.

DATE	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22
04/28/04	75	100	0	0	94	0	0	100	100	0	100	0	0	100	0	100	81	25	0	100	0	88
04/29/04	100	100	0	0	100	0	0	100	44	0	100	0	0	19	13	0	75	38	0	0	75	38
04/30/04	100	100	0	0	100	0	0	100	0	0	100	0	0	100	0	63	0	100	0	0	0	0
05/01/04	100	100	0	0	100	0	0	100	0	0	100	0	0	100	25	38	0	100	0	25	0	0
05/02/04	100	100	0	0	100	0	0	100	0	0	13	88	0	75	0	25	0	100	0	0	0	0
05/03/04	100	100	0	0	100	0	0	100	19	0	19	100	0	100	0	0	0	100	0	38	0	19
05/04/04	100	100	0	0	100	0	0	100	100	0	25	100	0	0	0	0	0	100	56	100	0	44
05/05/04	100	100	0	0	100	0	0	100	100	0	100	69	0	0	0	0	0	100	56	100	0	75
05/06/04	75	100	0	0	100	0	0	100	50	0	31		0	100	0	31	0	100	0	100	31	31
05/07/04	100	100	0	0	100	0	0	100	31	0	25	100	0	100	0	63	0	100	0	56	44	0
05/08/04	100	100	0	0	100	0	0	100	19	0	0	100	0	100	0	100	0	100	0	69	0	25
05/09/04	100	100	0	0	100	0	0	100	13	0	0	1001	13	100	0	100	0	100	0	25	0	25
05/10/04	100	100	0	0	100	0	0	100	25	0	13	100	100	6	13	100	0	6	100	0	44	0
05/11/04	100	100	0	0	100	0	0	100	75	0	19	100	6	0	100	0	0	100	100	0	100	0
05/12/04	100	100	0	0	100	0	0	100	100	0	100	19	100	0	100	0	0	100	100	0	100	0
05/13/04	100	100	0	0	100	0	0	100	50	0	44	100	81	0	44	50	0	100	13	56	6	50
05/14/04	100	100	0	0	100	0	0	100	100	0	0	100	100	0	100	0	0	100	25	63	19	38
05/15/04	100	100	0	0	100	0	0	100	100	0	0	100	100	0	100	0	0	100	38	0	38	0
05/16/04	100	100	0	0	100	0	0	100	44	0	13	100	100	0	94	0	0	100	0	0	0	0
05/17/04	100	100	0	0	100	0	0	100	100	0	0	100	100	0	100	0	0	100	0	100	0	75
05/18/04	100	100	0	0	100	0	0	100	56	0	19	100	81	0	100	0	0	100	0	94	6	81
05/19/04	100	100	0	0	100	0	0	100	19	0	0	100	100	0	0	100	0	100	94	0	75	0
05/20/04	100	100	0	0	100	0	0	100	81	0	100	19	100	13	56	0	0	100	100	13	100	0
05/21/04	94	94	0	0	100	0	0	100	100	0	100	75	100	0	0	0	63	75	19	75	56	44
05/22/04	100	100	0	0	100	0	0	100	100	0	100	0	100	100	0	0	25	44	0	100	0	100
05/23/04	100	100	0	0	100	0	0	100	100	0	100	0	100	6	100	0	63	0	13	63	0	56
05/24/04	100	100	0	0	100	0	0	100	100	0	100	0	100	88	25	0	38	0	75	38	100	0
05/25/04	100	100	0	0	100	0	0	100	100	0	100	0	100	100	88	0	0	38	0	6	69	81
05/26/04	100	100	0	0	100	0	0	100	100	0	88	0	100	13	50	0	0	63	0	100	88	100
05/27/04	100	100	0	0	100	0	0	100	100	0	100	0	100	88	19	0	0	31	81	100	75	100
05/28/04	100	88	0	0	100	0	0	100	100	0	100	0	100	100	0	0	0	0	100	100	100	100
05/29/04	100	100	0	0	100	0	0	100	100	0	100	0	100	100	0	0	0	0	100	100	100	100

Appendix E. Percentages of time spill bays (S) 1 through 9 were operating during the day by date at The Dalles Dam, spring 2004. No spill discharge occurred at bays S10 through S23. Darker colors indicate higher percentage. Day refers to 0530 to 2059 hours.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
04/28/04	100	100	100	100	100	100	94	13	13
04/29/04	100	100	100	100	100	100	0	0	0
04/30/04	100	100	100	100	100	100	13	0	0
05/01/04	100	100	100	100	100	100	0	0	0
05/02/04	100	100	100	100	100	100	0	0	0
05/03/04	100	100	100	100	100	100	19	0	0
05/04/04	100	100	100	100	100	100	0	0	0
05/05/04	100	100	100	100	100	100	0	0	0
05/06/04	100	100	100	100	100	100	38	0	0
05/07/04	100	100	100	100	100	100	0	0	0
05/08/04	100	100	100	100	100	100	19	0	0
05/09/04	100	100	100	100	100	100	0	0	0
05/10/04	100	100	100	100	100	100	0	0	0
05/11/04	100	100	100	100	100	100	13	0	0
05/12/04	100	100	100	100	100	100	0	0	0
05/13/04	100	100	100	100	100	100	31	0	0
05/14/04	100	100	100	100	100	100	6	0	0
05/15/04	100	100	100	100	100	100	0	0	0
05/16/04	100	100	100	100	100	100	0	0	0
05/17/04	100	100	100	100	100	100	19	6	0
05/18/04	100	100	100	100	100	100	0	0	0
05/19/04	100	100	100	100	100	100	6	0	0
05/20/04	100	100	100	100	100	100	25	0	0
05/21/04	100	100	100	100	100	100	13	0	0
05/22/04	100	100	100	100	100	100	50	0	0
05/23/04	100	100	100	100	100	100	56	13	0
05/24/04	100	100	100	100	100	100	100	31	0
05/25/04	100	100	100	100	100	100	0	0	0
05/26/04	100	100	100	100	100	100	0	0	0
05/27/04	100	100	100	100	100	100	6	0	0
05/28/04	100	100	100	100	100	100	6	0	0
05/29/04	100	100	100	100	100	100	81	0	0

Appendix F. Percentages of time turbines (T) 1 through 21 were operating at night by date at The Dalles Dam, spring 2004. Fish turbine units 1 and 2 operated throughout the study. Darker colors indicate higher percentage. Night refers to 2100 to 0529 hours.

Date	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22
04/28/04	100	100	0	0	100	0	0	44	100	0	100	0	0	100	0	100	11	100	0	67	0	44
04/29/04	100	100	0	0	100	0	0	100	67	0	100	0	0	100	0	11	0	100	0	0	33	0
04/30/04	100	100	0	0	100	0	0	100	0	0	100	0	0	100	0	78	0	100	0	0	22	0
05/01/04	100	100	0	0	100	0	0	100	0	0	100	0	0	100	33	67	0	100	0	0	0	0
05/02/04	100	100	0	0	100	0	0	100	0	0	67	33	0	100	0	22	0	100	0	0	0	0
05/03/04	100	100	0	0	100	0	0	100	33	0	11	100	0	100	0	0	0	100	0	33	0	33
05/04/04	100	100	0	0	100	0	0	100	100	0	33	100	0	11	0	0	0	100	33	100	0	44
05/05/04	100	100	0	0	100	0	0	100	100	0	100	100	0	0	0	0	0	100	67	100	0	56
05/06/04	100	100	0	0	100	0	0	100	100	0	67	100	0	67	0	33	0	100	0	100	33	67
05/07/04	100	100	0	0	100	0	0	100	0	0	0	100	0	100	0	100	0	100	0	100	67	0
05/08/04	100	100	0	0	100	0	0	100	33	0	0	100	0	100	0	100	0	100	0	100	0	33
05/09/04	100	100	0	0	100	0	0	100	67	0	0	100	33	100	0	100	0	100	0	67	0	67
05/10/04	100	100	0	0	100	0	0	100	33	0	22	100	89	44	33	89	0	100	44	0	33	0
05/11/04	100	100	0	0	100	0	0	100	100	0	33	89	33	0	100	0	0	100	100	0	100	0
05/12/04	100	100	0	0	100	0	0	100	78	0	78	33	100	0	100	0	0	100	89	0	89	0
05/13/04	100	100	0	0	100	0	0	100	56	0	22	100	100	0	100	0	0	100	33	56	33	56
05/14/04	100	100	0	0	100	0	0	100	100	0	0	100	100	0	100	0	0	100	44	0	33	0
05/15/04	100	100	0	0	100	0	0	100	100	0	0	100	100	0	78	0	0	100	56	0	44	0
05/16/04	100	100	0	0	100	0	0	100	89	0	33	100	100	0	33	0	0	100	0	0	0	0
05/17/04	100	100	0	0	100	0	0	100	33	0	0	100	100	0	100	0	0	100	0	67	0	11
05/18/04	100	100	0	0	100	0	0	100	67	0	0	89	100	0	89	0	0	100	0	67	11	0
05/19/04	100	100	0	0	100	0	0	100	33	0	33	100	100	0	33	78	0	100	33	0	33	0
05/20/04	100	100	0	0	100	0	0	100	100	0	100	33	100	0	67	0	0	100	78	33	100	0
05/21/04	100	100	0	0	100	0	0	100	100	0	100	67	100	0	0	0	0	100	0	100	67	0
05/22/04	100	100	0	0	100	0	0	100	100	0	100	0	100	44	0	0	33	67	0	100	0	56
05/23/04	100	100	0	0	100	0	0	100	100	0	100	0	100	67	89	0	100	0	33	67	33	67
05/24/04	100	100	0	0	100	0	0	100	100	0	100	0	100	33	67	0	67	0	67	0	100	0
05/25/04	100	100	0	0	100	0	0	100	100	0	100	0	100	89	33	0	0	33	0	33	67	33
05/26/04	100	100	0	0	100	0	0	100	56	0	33	0	100	33	100	0	0	100	0	100	33	100
05/27/04	100	100	0	0	100	0	0	100	44	0	33	0	100	33	67	0	0	67	33	100	33	100
05/28/04	100	100	0	0	100	0	0	100	100	0	100	0	100	100	0	0	0	0	100	100	100	100
05/29/04	100	100	0	0	100	0	0	100	100	0	100	0	100	100	0	0	0	0	100	100	100	100

Appendix G. Percentages of time spill bays (S) 1 through 9 were operating at night by date at The Dalles Dam, spring 2004. No spill discharge occurred at spill bays S10 through S23. Darker colors indicate higher percentage. Night refers to 2100 to 0529 hours.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9
04/28/04	100	100	100	100	100	100	67	67	44
04/29/04	100	100	100	100	100	100	0	0	0
04/30/04	100	100	100	100	100	100	0	0	0
05/01/04	100	100	100	100	100	100	0	0	0
05/02/04	100	100	100	100	100	100	0	0	0
05/03/04	100	100	100	100	100	100	33	0	0
05/04/04	100	100	100	100	100	100	0	0	0
05/05/04	100	100	100	100	100	100	0	0	0
05/06/04	100	100	100	100	100	100	89	0	0
05/07/04	100	100	100	100	100	100	0	0	0
05/08/04	100	100	100	100	100	100	33	0	0
05/09/04	100	100	100	100	100	100	0	0	0
05/10/04	100	100	100	100	100	100	0	0	0
05/11/04	100	100	100	100	100	100	0	0	0
05/12/04	100	100	100	100	100	100	0	0	0
05/13/04	100	100	100	100	100	100	44	0	0
05/14/04	100	100	100	100	100	100	0	0	0
05/15/04	100	100	100	100	100	100	0	0	0
05/16/04	100	100	100	100	100	100	0	0	0
05/17/04	100	100	100	100	100	100	22	0	0
05/18/04	100	100	100	100	100	100	0	0	0
05/19/04	100	100	100	100	100	100	22	22	0
05/20/04	100	100	100	100	100	100	11	0	0
05/21/04	100	100	100	100	100	100	0	0	0
05/22/04	100	100	100	100	100	100	44	0	0
05/23/04	100	100	100	100	100	100	78	44	0
05/24/04	100	100	100	100	100	100	100	0	0
05/25/04	100	100	100	100	100	100	11	0	0
05/26/04	100	100	100	100	100	100	0	0	0
05/27/04	100	100	100	100	100	100	0	0	0
05/28/04	100	100	100	100	100	100	33	0	0
05/29/04	100	100	100	100	100	100	67	0	0

Appendix H. Results of tests of overall diel location effects at the upriver entrance on fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) and log-ratio comparisons of FPE, SPE, and SLPE between groups of yearling Chinook salmon located at each of the upriver entrance areas above The Dalles Dam, 28 April through 29 May 2004. BN = barge north. BS = barge south. SS = south shore. The north shore was excluded from the logistic regression because of small sample sizes. The overall location effect was adjusted for 3 seasonal periods (see Figures 15 through 17). An asterisk (*) indicates significant effect or difference. *P*-values are based on the binomial-likelihood chi-square test (^{B}) or the quasi-likelihood F-test (^{Q}).

Passage efficiency	Test	Day *P*-value	Night *P*-value
FPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.7259^{Q}	0.0102^{B}*
	BN vs. BS	NA	0.0118*
	BN vs. SS	NA	0.0547
	BS vs. SS	NA	0.8097
SPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.4574^{B}	0.0071^{B}*
	BN vs. BS	NA	0.0063*
	BN vs. SS	NA	0.0736
	BS vs. SS	NA	0.5991
SLPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.8091^{B}	0.8616^{Q}

Test for overdispersion HO: Variance component for time period = 0

	Day			Night		
	Deviance	df	*P*	Deviance	df	*P*
FPE	10.729	6	0.0971	3.118	6	0.7940
SPE	8.650	6	0.1943	4.867	6	0.5608
SLPE	8.570	6	0.1992	12.394	6	0.0537

Residual analysis summary

Deviance residuals for the day and night analyses of FPE, SPE, and SLPE showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix I. Results of tests of overall diel location effects at the downriver entrance on fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) and log-ratio comparisons of FPE, SPE, and SLPE between groups of yearling Chinook salmon located at each of the downriver entrance areas above The Dalles Dam, 28 April through 29 May 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. The overall location effect was adjusted for 3 seasonal periods (see Figures 15 through 17). An asterisk (*) indicates significant effect or difference. *P*-values are based on the binomial-likelihood chi-square test.

Passage efficiency	Test	Day *P*-value	Night *P*-value
FPE	HO: No location effect (adjusted for 3 seasonal time periods)	<0.0025*	<0.0001*
	NS vs. BN	0.1489	0.6922
	NS vs. BS	0.4168	0.3166
	NS vs. SS	0.5671	0.0003*
	BN vs. BS	0.4649	0.3461
	BN vs. SS	0.0003*	0.0001*
	BS vs. SS	0.0371*	0.0074*
SPE	HO: No location effect (adjusted for 3 seasonal time periods)	<0.0001*	<0.0001*
	NS vs. BN	0.7984	0.0571
	NS vs. BS	0.4307	0.0106*
	NS vs. SS	0.0004*	<0.0001*
	BN vs. BS	0.0701	0.1651
	BN vs. SS	<0.0001*	<0.0001*
	BS vs. SS	<0.0001*	<0.0001*
SLPE	HO: No location effect (adjusted for 3 seasonal time periods)	<0.0001*	<0.0001*
	NS vs. BN	0.8455	0.2072
	NS vs. BS	0.4921	0.0840
	NS vs. SS	0.0015*	<0.0001*
	BN vs. BS	0.1331	0.3369
	BN vs. SS	<0.0001*	<0.0001*
	BS vs. SS	0.0001*	0.0115*

Test for overdispersion HO: Variance component for time period = 0

	Day			Night		
	Deviance	df	*P*	Deviance	df	*P*
FPE	6.867	8	0.5510	3.969	8	0.8599
SPE	10.083	8	0.2592	7.900	8	0.4433
SLPE	12.276	8	0.1393	10.502	8	0.2315

Residual analysis summary

Deviance residuals for the day and night analyses of FPE, SPE, and SLPE showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix J. Estimates of yearling Chinook salmon sluiceway passage efficiency (SLPE) during operation of main turbine unit (MU) 01 and MU18 sluiceway entrances and the MU01 entrance only by block, and logistic regression results comparing the treatments, 28 April through 29 May 2004. Treatments: MU18+MU01 = MU18 and MU01 entrances open, MU01 = MU01 entrances open. LRCI = profile-likelihood confidence interval. *N* = sample size adjusted for detection efficiencies.

	Treatment						
	MU18 + MU01			MU01			Observed
Block	SLPE	N	Odds	SLPE	N	Odds	odds ratio
05	7.1	70	0.076	28.6	7	0.400	5.263
06	6.9	58	0.074	7.1	70	0.076	1.027
07	1.4	73	0.014	13.2	68	0.152	10.857
08	13.2	68	0.152	8.9	79	0.098	0.645
09	9.1	65	0.100	19.2	73	0.238	2.380
10	4.3	69	0.045	10.9	55	0.122	2.711
11	3.3	60	0.034	7.6	66	0.082	2.412
12	4.4	68	0.046	7.3	68	0.078	1.696
13	9.0	67	0.099	8.7	69	0.095	0.960
14	9.0	67	0.099	2.8	71	0.029	0.293
15	6.2	64	0.066	7.8	64	0.085	1.288
16	6.0	67	0.064	7.6	66	0.082	1.281
18	13.2	68	0.152	8.8	57	0.096	0.632
19	4.5	66	0.047	10.9	64	0.122	2.596
20	12.3	81	0.151	11.8	76	0.134	0.887
Overall odds ratio adjusted for block (95% LRCI)							1.355 (0.980 – 1.882)

Test HO: odds ratio = 1 (no sluiceway treatment effect, chi-square test, *P* = 0.0664)

Test for overdispersion HO: Variance component for block = 0			
	Deviance	df	*P*
SLPE	36.396	28	0.1328

Residual analysis summary
Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix K. Estimates of yearling Chinook salmon fish passage efficiency (FPE) during two sluiceway operation treatments by block and logistic regression results comparing the treatments, 28 April through 29 May 2004. Treatments: MU18+MU01 = MU18 and MU01 entrances open, MU01 = MU01 entrances open. LRCI = profile-likelihood confidence interval. QRCI = quasi-likelihood confidence ratio. *N* = sample size adjusted for detection efficiencies.

	MU18 + MU01			MU01			Observed
Block	FPE	*N*	Odds	FPE	*N*	Odds	odds ratio
05	92.9	70	13.084	85.7	7	5.993	0.458
06	98.3	58	57.823	97.1	70	33.483	0.579
07	95.9	73	23.390	92.6	68	12.514	0.535
08	92.6	68	12.513	97.5	79	39.000	3.117
09	89.4	65	8.434	87.7	73	7.130	0.845
10	89.9	69	8.901	90.9	55	9.989	1.122
11	85.0	60	5.667	83.3	66	4.988	0.880
12	94.1	68	15.949	89.7	68	8.709	0.546
13	97.0	67	32.333	95.6	69	21.727	0.672
14	95.5	67	21.222	93.0	71	13.286	0.626
15	100.0	64	-	96.9	64	31.258	< 1.000
16	94.0	67	15.667	95.4	66	20.739	1.324
18	85.3	68	5.803	89.5	57	8.524	1.469
19	92.4	66	12.158	93.7	64	14.873	1.223
20	96.3	81	26.027	96.0	76	24.000	0.922

Overall odds ratio adjusted for date (95% QRCI) 0.917 (0.646 – 1.302)

Test HO: odds ratio = 1 (no sluiceway treatment effect, F-test, *P* = 0.5476)

Test for overdispersion HO: Variance component for block = 0			
	Deviance	df	*P*
FPE	62.253	28	0.0002

Residual analysis summary
Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix L. Diel estimates of yearling Chinook salmon fish passage efficiency (FPE) during 40% bulk spill discharge by date and logistic regression results comparing diel periods, spring 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = quasi-likelihood confidence interval. *N* = adjusted sample size.

	Day			Night			Observed
DATE	FPE	*N*	Odds	FPE	*N*	Odds	odds ratio
28 Apr	95.6	45	21.727	90.0	10	9.000	0.414
29 Apr	100.0	41	-	85.0	20	5.667	< 1.000
30 Apr	98.3	59	57.823	90.9	11	9.989	0.173
01 May	93.0	57	13.286	87.5	16	7.000	0.527
02 May	96.1	51	24.641	100.0	12	-	> 1.000
03 May	94.5	55	17.182	100.0	23	-	> 1.000
04 May	98.0	51	49.000	91.7	24	11.048	0.225
05 May	94.9	39	18.608	74.1	27	2.861	0.154
06 May	97.4	38	37.461	76.5	34	3.255	0.087
07 May	100.0	34	-	78.3	23	3.608	< 1.000
08 May	91.9	37	11.346	88.5	26	7.696	0.679
09 May	94.6	37	17.518	70.4	27	2.378	0.136
10 May	95.1	41	19.408	63.0	27	1.703	0.088
11 May	94.4	54	16.857	84.2	19	5.329	0.316
12 May	97.9	47	46.619	78.3	23	3.608	0.077
13 May	97.6	42	40.667	88.5	26	7.696	0.189
14 May	96.3	54	26.027	92.0	25	11.500	0.442
15 May	96.4	56	26.778	90.0	10	9.000	0.336
16 May	98.2	55	54.556	81.8	11	4.494	0.082
17 May	100.0	44	-	83.3	24	4.988	< 1.000
18&19 May	98.0	100	49.000	96.4	28	26.778	0.546
20 May	96.0	50	24.000	92.9	14	13.084	0.545
21 May	100.0	50	-	91.7	12	11.048	< 1.000
22 May	100.0	45	-	80.0	15	4.000	< 1.000
23 May	93.9	33	15.393	80.8	26	4.208	0.273
24 May	100.0	47	-	56.0	25	1.273	< 1.000
25 May	100.0	51	-	53.3	15	1.141	< 1.000
26 May	98.0	50	49.000	72.7	11	2.663	0.054
27 May	96.7	60	29.303	77.8	9	3.504	0.120
28 May	98.2	57	54.556	90.9	11	9.989	0.183
29 May	97.1	34	33.483	66.7	3	2.003	0.060
Overall odds ratio adjusted for date (95% QRCI						0.144 (0.086 - 0.234)	
Test HO: odds ratio = 1 (no diel effect, F-test, *P* < 0.0001)							

<u>Test for overdispersion HO</u>: Variance component for date = 0, Deviance = 87.1293, df = 60, *P* < 0.0126.
<u>Residual analysis summary</u>: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix M. Diel estimates of yearling Chinook salmon spill passage efficiency (SPE) during 40% bulk spill discharge by date and logistic regression results comparing diel periods, spring 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = quasi-likelihood ratio confidence interval. *N* = sample size adjusted.

	Day			Night			Observed odds
Date	SPE	*N*	Odds	SPE	*N*	Odds	ratio
28 Apr	88.9	45	8.009	70.0	10	2.333	0.291
29 Apr	100.0	41	-	70.0	20	2.333	< 1.000
30 Apr	93.2	59	13.706	63.6	11	1.747	0.127
01 May	84.2	57	5.329	68.8	16	2.205	0.414
02 May	94.1	51	15.949	83.3	12	4.988	0.313
03 May	90.9	55	9.989	87.0	23	6.692	0.670
04 May	92.2	51	11.820	66.7	24	2.003	0.169
05 May	76.9	39	3.329	51.9	27	1.079	0.324
06 May	86.8	38	6.576	58.8	34	1.427	0.217
07 May	94.1	34	15.949	69.6	23	2.289	0.144
08 May	89.2	37	8.259	76.9	26	3.329	0.403
09 May	94.6	37	17.518	63.0	27	1.703	0.097
10 May	92.7	41	12.699	55.6	27	1.252	0.099
11 May	92.6	54	12.513	68.4	19	2.165	0.173
12 May	91.5	47	10.765	65.2	23	1.874	0.174
13 May	85.7	42	5.993	80.8	26	4.208	0.702
14 May	92.6	54	12.513	76.0	25	3.167	0.253
15 May	91.1	56	10.236	70.0	10	2.333	0.228
16 May	94.5	55	17.182	72.7	11	2.663	0.155
17 May	100.0	44	-	66.7	24	2.003	< 1.000
18&19 May	94.0	100	15.667	78.6	28	3.673	0.234
20 May	92.0	50	11.500	78.6	14	3.673	0.319
21 May	92.0	50	11.500	50.0	12	1.000	0.087
22 May	97.8	45	44.454	66.7	15	2.003	0.045
23 May	75.8	33	3.132	69.2	26	2.247	0.717
24 May	85.1	47	5.711	56.0	25	1.273	0.223
25 May	94.1	51	15.949	46.7	15	0.876	0.055
26 May	90.0	50	9.000	63.6	11	1.747	0.194
27 May	81.7	60	4.464	66.7	9	2.003	0.449
28 May	91.2	57	10.364	81.8	11	4.495	0.434
29 May	82.4	34	4.682	0.0	3	0.000	-
Overall odds ratio adjusted for date (95% QRCI)							0.207 (0.160 - 0.268)
Test HO: odds ratio = 1 (no diel effect, F-test, $P < 0.0001$)							

Test for overdispersion HO: Variance component for date = 0, Deviance = 89.0816, df = 62, P < 0.0137.
Residual analysis summary: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix N. Diel estimates of yearling Chinook salmon sluiceway passage efficiency (SLPE) during 40% bulk spill discharge at The Dalles Dam and logistic regression results comparing diel periods, spring 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = quasi-likelihood ratio confidence interval. *N* = sample size.

	Day			Night			Observed
Date	SLPE	*N*	Odds	SLPE	*N*	Odds	odds ratio
28 Apr	6.7	45	0.072	20.0	10	0.250	3.472
29 Apr	0.0	41	0.000	15.0	20	0.176	-
30 Apr	5.1	59	0.054	27.3	11	0.376	6.963
01 May	8.8	57	0.096	18.8	16	0.232	2.417
02 May	2.0	51	0.020	16.7	12	0.200	10.000
03 May	3.6	55	0.037	13.0	23	0.149	4.027
04 May	5.9	51	0.063	25.0	24	0.333	5.286
05 May	17.9	39	0.218	22.2	27	0.285	1.307
06 May	10.5	38	0.117	17.6	34	0.214	1.829
07 May	5.9	34	0.063	8.7	23	0.095	1.508
08 May	2.7	37	0.028	11.5	26	0.130	4.643
09 May	0.0	37	0.000	7.4	27	0.080	-
10 May	2.4	41	0.025	7.4	27	0.080	3.200
11 May	1.9	54	0.019	15.8	19	0.188	9.895
12 May	6.4	47	0.068	13.0	23	0.149	2.191
13 May	11.9	42	0.135	7.7	26	0.083	0.615
14 May	3.7	54	0.038	16.0	25	0.190	5.000
15 May	5.4	56	0.057	20.0	10	0.250	4.386
16 May	3.6	55	0.037	9.1	11	0.100	2.703
17 May	0.0	44	0.000	16.7	24	0.200	-
18&19 May	4.0	100	0.042	17.9	28	0.218	5.190
20 May	4.0	50	0.042	14.3	14	0.167	3.976
21 May	8.0	50	0.087	41.7	12	0.715	8.218
22 May	2.2	45	0.022	13.3	15	0.153	6.955
23 May	18.2	33	0.222	11.5	26	0.130	0.586
24 May	14.9	47	0.175	0.0	25	0.000	0.000
25 May	5.9	51	0.063	6.7	15	0.072	1.143
26 May	8.0	50	0.087	9.1	11	0.100	1.149
27 May	15.0	60	0.176	11.1	9	0.125	0.710
28 May	7.0	57	0.075	9.1	11	0.100	1.333
29 May	14.7	34	0.172	66.7	3	2.003	11.645
Overall odds ratio adjusted for date (95% QRCI)							2.665 (1.782 – 3.984)
Test HO: odds ratio = 1 (no diel effect, F-test, $P < 0.0001$)							

Test for overdispersion HO: Variance component for date = 0, Deviance = 82.7296, df = 62, P < 0.0175.

Residual analysis summary: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix O. The sample size (N), mean, standard deviation (SD), and range of fork lengths (mm) and weights (g) of subyearling Chinook salmon released from the John Day Dam tailrace during summer 2004.

			Fork length (mm)			Weight (g)		
Release		*N*	Mean	SD	Range	Mean	SD	Range
JDT0619	0600	31	115	4.6	109 - 126	16.2	2.0	13.0 - 21.8
JDT0619	1800	29	116	5.8	110 - 130	16.2	2.4	13.1 - 21.6
JDT0620	0600	30	119	6.5	110 - 136	17.4	2.9	13.7 - 24.9
JDT0620	1800	29	118	6.8	110 - 135	17.8	3.3	14.6 - 26.6
JDT0621	0600	31	120	7.7	111 - 138	18.2	3.4	14.6 - 28.0
JDT0621	1800	32	114	3.5	110 - 125	15.7	1.7	13.3 - 20.9
JDT0622	0600	30	124	8.4	111 - 143	20.9	4.4	15.4 - 32.2
JDT0622	1800	30	115	4.4	110 - 128	15.7	1.8	13.4 - 20.4
JDT0623	0600	31	118	6.8	109 - 133	18.0	3.2	14.2 - 25.0
JDT0623	1800	31	114	3.7	110 - 127	15.0	1.7	13.1 - 20.9
JDT0624	0600	31	115	4.3	108 - 125	15.7	1.9	13.0 - 21.6
JDT0624	1800	29	112	2.0	108 - 117	14.6	1.0	13.3 - 17.0
JDT0625	0600	30	116	7.3	110 - 150	15.8	3.6	13.3 - 32.8
JDT0625	1800	31	112	2.2	107 - 116	14.5	1.0	13.0 - 16.7
JDT0626	0600	22	115	10.5	108 - 160	15.6	5.9	13.0 - 41.2
JDT0626	1800	23	119	11.2	109 - 157	17.4	6.5	13.0 - 41.6
JDT0627	0600	25	118	10.2	109 - 152	16.9	5.4	13.0 - 36.3
JDT0627	1800	17	114	1.8	111 - 119	15.4	1.2	13.6 - 17.3
JDT0628	0600	16	113	1.4	110 - 115	15.2	1.5	13.0 - 18.3
JDT0628	1800	29	115	3.8	110 - 123	15.8	1.9	13.2 - 20.0
JDT0629	0600	29	117	9.3	107 - 141	17.3	4.4	13.4 - 28.7
JDT0629	1800	20	115	6.3	110 - 138	15.9	2.6	13.1 - 25.0
JDT0630	0600	20	113	2.5	109 - 118	14.7	1.5	13.1 - 18.4
JDT0630	1800	28	116	8.9	108 - 142	17.5	4.1	13.0 - 30.4
JDT0701	0600	27	115	7.0	107 - 136	15.8	3.5	13.2 - 25.9
JDT0701	1800	20	116	7.0	109 - 135	16.3	3.0	13.0 - 23.5
JDT0702	0600	20	112	2.8	106 - 117	14.7	1.1	13.2 - 17.0
JDT0702	1800	21	116	8.3	108 - 142	17.3	4.6	13.1 - 31.0
JDT0703	0600	22	116	7.7	108 - 138	17.2	4.0	13.8 - 29.4
JDT0703	1800	20	114	6.2	108 - 132	16.6	3.9	13.1 - 28.3
JDT0704	0600	19	116	11.0	105 - 148	16.7	5.5	13.0 - 35.0
JDT0704	1800	17	123	14.7	109 - 148	20.2	7.2	13.4 - 33.4
JDT0705	0600	17	120	10.5	110 - 141	18.9	5.6	13.2 - 29.2
JDT0705	1800	18	113	2.5	109 - 117	15.3	1.3	13.4 - 18.1
JDT0706	0600	18	115	7.5	109 - 141	16.3	3.9	13.2 - 30.1
JDT0706	1800	19	111	4.2	106 - 125	15.7	2.4	13.3 - 23.6
JDT0707	0600	19	118	11.4	110 - 148	17.9	6.6	13.0 - 35.9
JDT0707	1800	22	114	8.2	107 - 145	16.1	4.7	13.3 - 35.5
JDT0708	0600	20	120	12.9	106 - 149	18.3	6.6	13.1 - 36.8
JDT0708	1800	19	111	4.7	105 - 125	15.1	2.3	13.2 - 22.7

Appendix O. Continued.

Release		*N*	Fork length (mm)			Weight (g)		
			Mean	SD	Range	Mean	SD	Range
JDT0709	0600	13	116	8.8	106 - 133	16.9	3.9	13.2 - 26.1
JDT0709	1800	19	118	14.4	107 - 150	18.6	7.6	13.3 - 37.8
JDT0710	0600	14	114	10.1	106 - 146	15.7	5.5	13.1 - 34.4
JDT0710	1800	23	121	13.9	105 - 154	19.6	7.4	13.2 - 39.4
JDT0711	0600	23	125	12.8	114 - 175	20.6	8.5	13.5 - 56.3
JDT0711	1800	20	115	8.8	107 - 144	16.0	3.6	13.1 - 27.5
JDT0712	0600	20	117	10.0	110 - 146	16.7	4.6	13.0 - 29.8
JDT0712	1800	16	116	10.3	108 - 149	17.2	5.1	13.2 - 34.5
JDT0713	0600	14	126	9.6	110 - 140	20.3	4.2	14.0 - 28.5
JDT0713	1800	20	124	12.5	105 - 145	19.7	5.8	13.3 - 30.3
JDT0714	0600	18	131	18.4	108 - 163	26.1	11.8	13.1 - 53.0
JDT0714	1800	28	115	9.7	105 - 141	17.4	4.0	13.6 - 30.3
JDT0715	0600	24	116	9.8	105 - 142	17.2	4.4	13.6 - 31.5
JDT0715	1800	22	115	10.1	107 - 147	16.1	5.1	13.0 - 32.6
JDT0716	0600	24	118	9.6	105 - 154	18.7	5.7	13.8 - 42.2
JDT0716	1800	29	117	8.9	107 - 137	17.4	3.8	13.1 - 26.5
JDT0717	0600	31	129	14.9	107 - 167	22.5	8.1	13.0 - 52.3
JDT0717	1800	33	116	7.2	106 - 138	17.1	3.2	13.4 - 28.6
JDT0718	0600	20	117	10.6	106 - 153	17.0	4.2	13.1 - 31.4
JDT0718	1800	29	115	8.2	105 - 137	17.3	3.0	13.8 - 25.0
JDT0719	0600	33	117	8.0	106 - 137	17.7	3.5	13.3 - 25.6
JDT0719	1800	33	115	9.8	105 - 147	16.7	4.4	13.0 - 33.5
JDT0720	0600	31	115	8.4	107 - 145	16.1	3.4	13.2 - 28.9
JDT0720	1800	32	116	12.7	103 - 165	19.3	8.7	13.0 - 56.3
JDT0721	0600	35	118	9.7	107 - 157	18.3	5.2	13.3 - 42.2
JDT0721	1800	35	111	5.7	105 - 125	15.2	2.3	13.0 - 22.5
JDT0722	0600	34	116	11.4	106 - 156	17.7	5.9	13.3 - 41.5
JDT0722	1800	33	113	11.2	102 - 150	16.7	4.8	13.0 - 33.4
JDT0723	0600	36	114	8.9	104 - 134	16.8	4.1	13.3 - 28.4
JDT0723	1800	21	111	5.7	103 - 120	15.4	1.9	13.0 - 19.3
JDT0724	0600	31	115	7.5	105 - 129	17.9	3.4	13.6 - 27.6
JDT0724	1800	52	110	5.3	103 - 126	15.8	2.1	13.2 - 22.6
JDT0725	0600	50	112	7.5	102 - 135	17.0	3.2	13.5 - 29.5
JDT0725	1800	50	113	7.2	103 - 140	16.2	2.7	13.3 - 25.8
JDT0726	0600	63	113	6.7	104 - 142	16.5	2.9	13.1 - 29.2
JDT0726	1800	57	111	6.6	100 - 130	17.6	3.0	13.0 - 28.5
JDT0727	0600	60	112	8.5	102 - 147	16.7	3.7	13.1 - 33.1
JDT0727	1800	35	110	5.5	103 - 130	15.5	2.4	13.2 - 25.7
JDT0728	0600	32	112	8.6	102 - 136	16.4	3.7	13.0 - 27.8
JDT0728	1800	45	109	6.1	101 - 130	16.5	2.7	13.0 - 26.8
Overall		2210	115	9.2	100 - 175	17.0	4.5	13.0 - 56.3

Appendix P. Number of radio-tagged subyearling Chinook salmon passing via the powerhouse, sluiceway, and spillway by diel period and date at The Dalles Dam during 40% bulk spill, summer 2004.

Date	Diel	Powerhouse	Sluiceway	Spillway
06/19/04	Day	0	1	5
06/19/04	Night	1	0	9
06/20/04	Day	3	0	40
06/20/04	Night	1	0	9
06/21/04	Day	4	1	38
06/21/04	Night	6	0	8
06/22/04	Day	5	1	40
06/22/04	Night	8	1	12
06/23/04	Day	4	1	35
06/23/04	Night	5	0	3
06/24/04	Day	13	1	20
06/24/04	Night	7	0	10
06/25/04	Day	3	0	38
06/25/04	Night	3	0	12
06/26/04	Day	3	2	32
06/26/04	Night	2	0	11
06/27/04	Day	1	2	24
06/27/04	Night	7	1	8
06/28/04	Day	0	0	24
06/28/04	Night	4	1	12
06/29/04	Day	5	0	35
06/29/04	Night	0	1	7
06/30/04	Day	4	0	29
06/30/04	Night	3	1	8
07/01/04	Day	2	0	34
07/01/04	Night	6	0	4
07/02/04	Day	3	1	19
07/02/04	Night	3	2	9
07/03/04	Day	0	0	21
07/03/04	Night	1	0	8
07/04/04	Day	1	1	25
07/04/04	Night	2	2	10
07/05/04	Day	0	0	22
07/05/04	Night	5	1	7
07/06/04	Day	1	0	25
07/06/04	Night	4	0	7
07/07/04	Day	1	2	26
07/07/04	Night	3	2	1
07/08/04	Day	2	2	24
07/08/04	Night	2	1	5
07/09/04	Day	2	3	21
07/09/04	Night	3	1	0
07/10/04	Day	0	0	23
07/10/04	Night	2	0	4
07/11/04	Day	1	0	26
07/11/04	Night	6	1	4
07/12/04	Day	0	2	18

Appendix P. Continued.

Date	Diel	Powerhouse	Sluiceway	Spillway
07/12/04	Night	2	0	11
07/13/04	Day	1	0	16
07/13/04	Night	4	0	7
07/14/04	Day	0	1	26
07/14/04	Night	1	1	5
07/15/04	Day	1	4	29
07/15/04	Night	2	3	2
07/16/04	Day	2	1	23
07/16/04	Night	3	1	8
07/17/04	Day	0	4	35
07/17/04	Night	1	1	11
07/18/04	Day	0	5	18
07/18/04	Night	3	1	4
07/19/04	Day	1	10	33
07/19/04	Night	8	3	10
07/20/04	Day	1	4	24
07/20/04	Night	4	0	6
07/21/04	Day	2	6	31
07/21/04	Night	7	0	10
07/22/04	Day	4	2	31
07/22/04	Night	7	1	11
07/23/04	Day	3	5	32
07/23/04	Night	8	2	4
07/24/04	Day	0	0	17
07/24/04	Night	6	1	13
07/25/04	Day	1	1	20
07/25/04	Night	5	2	8
07/26/04	Day	6	12	41
07/26/04	Night	13	2	16
07/27/04	Day	2	6	39
07/27/04	Night	11	1	10
07/28/04	Day	5	2	37
07/28/04	Night	10	2	13
07/29/04	Day	2	5	29
07/29/04	Night	3	0	7

Appendix Q. Percentages of time turbines (T) 1 through 21 were operating during the day by date at The Dalles Dam, summer 2004. Darker colors indicate higher percentage. Day refers to 0530 to 2059 hours.

Date	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22
06/19/04	0	0	0	0	100	0	0	100	0	0	100	100	100	44	100	0	0	100	81	0	13	100
06/20/04	0	0	0	0	100	0	0	100	0	0	100	6	100	0	100	0	0	100	88	0	19	0
06/21/04	0	0	0	0	100	0	0	100	88	0	100	44	100	63	81	13	63	100	44	81	50	69
06/22/04	0	0	0	0	100	0	0	100	38	0	69	38	94	63	100	0	56	100	50	100	44	88
06/23/04	0	0	0	0	100	0	0	100	0	0	100	100	63	100	100	0	56	100	100	50	100	0
06/24/04	0	0	0	0	100	0	0	100	0	0	50	100	38	100	100	0	25	100	25	94	25	94
06/25/04	0	0	0	0	100	0	0	94	94	0	75	100	0	100	0	0	0	100	0	100	0	94
06/26/04	0	0	0	0	100	0	0	75	100	0	88	0	0	100	75	0	0	100	0	100	0	100
06/27/04	0	0	0	0	100	0	0	81	25	0	100	0	63	0	100	0	0	100	0	100	0	100
06/28/04	0	0	0	0	100	0	0	44	100	0	100	69	100	0	100	0	0	100	0	88	0	88
06/29/04	0	0	0	0	100	0	0	100	100	0	75	56	75	56	100	0	100	19	19	75	94	0
06/30/04	0	0	0	0	100	0	0	100	100	0	94	81	94	25	100	6	0	100	100	0	75	0
07/01/04	6	0	0	0	100	0	0	100	38	0	31	50	100	0	63	69	0	100	0	100	0	100
07/02/04	0	0	0	0	100	0	0	100	88	0	0	0	0	100	0	100	0	100	0	100	0	44
07/03/04	6	0	0	0	100	0	0	100	44	0	69	0	0	100	0	63	0	100	0	50	0	0
07/04/04	0	0	0	0	100	0	0	100	100	0	100	0	69	88	0	88	0	100	0	81	0	75
07/05/04	0	0	0	0	100	0	0	100	100	0	100	0	0	100	13	81	0	100	0	81	0	19
07/06/04	0	0	0	0	100	0	0	100	100	0	100	0	50	75	0	0	31	100	94	0	88	0
07/07/04	69	0	0	0	100	0	0	100	0	0	100	0	94	0	75	69	0	100	0	94	0	31
07/08/04	100	63	0	0	100	0	0	100	0	0	100	0	0	100	100	0	0	100	0	31	0	25
07/09/04	100	88	0	0	100	0	0	100	0	0	100	0	81	0	81	0	0	100	0	56	0	0
07/10/04	100	0	0	0	100	0	0	100	0	0	100	0	100	0	88	0	0	100	0	81	0	0
07/11/04	100	0	0	0	100	0	0	100	0	0	100	0	81	0	69	0	0	100	0	44	0	0
07/12/04	100	88	0	0	100	0	0	100	13	0	100	0	100	0	63	0	0	100	0	50	0	0
07/13/04	100	100	0	0	100	0	0	100	0	0	0	100	0	38	69	0	0	63	0	13	0	0
07/14/04	100	100	0	0	100	0	0	100	0	0	100	0	100	0	50	0	0	100	0	44	0	0
07/15/04	100	100	0	0	100	0	0	100	0	0	56	0	0	56	0	19	0	100	0	50	0	0
07/16/04	100	100	0	0	100	0	0	100	94	0	19	0	0	0	0	0	0	100	0	0	0	0
07/17/04	100	100	0	0	81	0	0	100	0	0	13	100	0	0	0	0	0	100	0	0	0	0
07/18/04	100	69	0	0	0	0	0	100	0	0	0	81	0	0	0	0	0	100	0	0	0	0
07/19/04	100	100	0	0	0	0	0	100	31	0	0	100	56	88	0	38	0	0	0	81	0	0
07/20/04	100	100	0	0	0	0	0	100	0	0	0	100	0	63	0	44	0	0	0	6	0	0
07/21/04	100	100	0	0	0	0	0	100	0	0	0	100	0	25	19	0	0	0	13	0	0	0
07/22/04	100	100	0	0	38	0	0	100	0	0	0	100	0	44	13	0	0	0	0	0	0	0
07/23/04	100	100	0	0	100	0	0	100	94	0	75	0	31	0	25	0	0	0	25	0	0	0
07/24/04	100	100	0	0	100	0	0	100	100	0	0	19	13	0	0	0	0	0	0	0	0	0
07/25/04	100	100	0	0	0	0	0	100	100	0	81	19	44	0	6	0	0	0	0	0	0	0
07/26/04	100	88	0	0	69	0	69	100	100	0	94	0	69	0	63	0	0	0	19	0	0	0
07/27/04	100	100	0	0	100	0	38	81	94	0	81	0	81	0	0	0	0	0	0	0	0	0
07/28/04	6	100	0	0	100	0	31	100	100	0	100	0	0	69	38	0	0	0	38	0	0	0
07/29/04	0	100	0	0	100	0	0	100	100	0	100	0	81	0	44	0	0	0	38	0	0	0

Appendix R. Percentages of time spill bay (S) 1 through 10 were operating during the day by date at The Dalles Dam, summer 2004. No spill discharge occurred at spill bays S11 through S23. Darker colors indicate higher percentage. Day refers to 0530 to 2059 hours.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
06/19/04	100	100	100	100	100	100	100	0	0	0
06/20/04	100	100	100	100	100	100	50	0	0	0
06/21/04	100	100	100	100	100	100	50	19	0	0
06/22/04	100	100	100	100	100	100	56	25	19	0
06/23/04	100	100	100	100	100	100	19	0	0	0
06/24/04	100	100	100	100	100	100	0	0	0	0
06/25/04	100	100	100	100	100	100	0	0	0	0
06/26/04	100	100	100	100	100	100	0	0	0	0
06/27/04	100	100	100	100	100	100	56	0	0	0
06/28/04	100	100	100	100	100	100	88	6	0	0
06/29/04	100	100	100	100	100	100	100	38	38	19
06/30/04	100	100	100	100	100	100	56	13	0	0
07/01/04	100	100	100	100	100	100	44	0	0	0
07/02/04	100	100	100	100	100	100	0	0	0	0
07/03/04	100	100	100	100	100	100	0	0	0	0
07/04/04	100	100	100	100	100	100	44	0	0	0
07/05/04	100	100	100	100	100	100	25	0	0	0
07/06/04	100	100	100	100	100	100	38	6	6	0
07/07/04	100	100	100	100	100	100	88	75	0	0
07/08/04	100	100	100	100	100	100	25	13	0	0
07/09/04	100	100	100	100	100	100	88	0	0	0
07/10/04	100	100	100	100	100	100	56	0	0	0
07/11/04	100	100	100	100	100	100	69	0	0	0
07/12/04	100	100	100	100	100	100	100	81	44	25
07/13/04	100	100	100	100	100	100	94	81	25	19
07/14/04	100	100	100	100	100	100	50	0	0	0
07/15/04	100	100	100	100	100	100	0	0	0	0
07/16/04	100	100	100	100	100	100	0	0	0	0
07/17/04	100	100	100	100	100	100	0	0	0	0
07/18/04	63	100	100	100	100	100	0	0	0	0
07/19/04	100	100	100	100	100	100	13	0	0	0
07/20/04	100	100	100	100	100	100	0	0	0	0
07/21/04	100	100	100	100	100	100	0	0	0	0
07/22/04	100	100	100	100	100	100	0	0	0	0
07/23/04	100	100	100	100	100	100	0	0	0	0
07/24/04	100	100	100	100	100	100	0	0	0	0
07/25/04	100	100	100	100	100	100	0	0	0	0
07/26/04	100	100	100	100	100	100	19	0	0	0
07/27/04	100	100	100	100	100	100	0	0	0	0
07/28/04	100	100	100	100	100	100	0	0	0	0
07/29/04	100	100	100	100	100	100	0	0	0	0

Appendix S. Percentages of time turbines (T) 1 through 21 were operating during the Night by date at The Dalles Dam, summer 2004. Darker colors indicate higher percentage. Night refers to 2100 to 0529 hours.

Date	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22
06/19/04	0	0	0	0	100	0	0	100	0	0	100	78	100	67	100	56	0	100	33	22	56	89
06/20/04	0	0	0	0	100	0	0	100	0	0	100	33	100	11	100	11	0	100	78	0	33	0
06/21/04	0	0	0	0	100	0	0	100	22	0	100	44	100	33	100	0	22	100	67	33	67	11
06/22/04	0	0	0	0	100	0	0	100	22	0	100	33	100	33	100	0	33	100	33	100	33	44
06/23/04	0	0	0	0	100	0	0	100	0	0	100	100	67	100	100	0	67	100	100	67	89	0
06/24/04	0	0	0	0	100	0	0	89	0	0	67	100	0	100	89	0	0	100	0	33	0	33
06/25/04	0	0	0	0	100	0	0	33	33	0	0	100	0	100	0	0	0	100	0	100	0	33
06/26/04	0	0	0	0	100	0	0	67	100	0	33	33	0	100	33	0	0	100	0	100	0	100
06/27/04	0	0	0	0	100	0	0	67	78	0	100	0	33	33	100	0	0	100	0	100	0	100
06/28/04	0	0	0	0	100	0	0	56	100	0	100	22	100	0	89	0	0	89	0	67	0	44
06/29/04	0	0	0	0	100	0	0	100	100	0	100	22	100	22	33	0	11	33	33	11	33	0
06/30/04	0	0	0	0	89	0	0	44	78	0	67	33	67	33	100	0	0	100	100	0	33	0
07/01/04	0	0	0	0	44	0	0	100	33	0	33	33	67	22	67	33	0	100	11	56	0	44
07/02/04	0	0	0	0	100	0	0	100	56	0	22	33	22	67	0	100	0	100	0	100	0	67
07/03/04	0	0	0	0	100	0	0	100	33	0	33	0	0	89	0	33	0	100	0	22	0	22
07/04/04	0	0	0	0	100	0	0	100	100	0	100	0	0	33	0	33	0	100	0	11	0	0
07/05/04	0	0	0	0	100	0	0	100	100	0	100	0	0	100	33	0	0	100	0	33	0	33
07/06/04	0	0	0	0	100	0	0	100	89	0	100	0	33	67	0	0	0	100	33	44	33	22
07/07/04	33	0	0	0	100	0	0	100	0	0	100	0	44	0	22	33	0	100	0	33	0	0
07/08/04	100	0	0	0	100	0	0	100	0	0	100	0	33	56	44	22	0	100	0	33	0	22
07/09/04	100	22	0	0	100	0	0	100	0	0	100	0	33	0	22	0	0	100	0	22	0	0
07/10/04	100	0	0	0	100	0	0	100	0	0	100	0	100	0	22	0	0	100	0	0	0	0
07/11/04	100	0	0	0	100	0	0	100	0	0	100	0	33	0	33	0	0	100	0	0	0	0
07/12/04	100	33	0	0	100	0	0	100	33	0	100	22	44	0	33	0	0	100	0	33	0	0
07/13/04	100	100	0	0	100	0	0	100	22	0	11	100	0	33	44	0	0	100	0	33	0	0
07/14/04	100	100	0	0	100	0	0	100	0	0	44	33	44	0	22	0	0	100	0	11	0	0
07/15/04	100	100	0	0	100	0	0	100	0	0	44	0	0	11	0	0	0	100	0	22	0	0
07/16/04	100	100	0	0	100	0	0	100	33	0	33	0	0	0	0	0	0	100	0	0	0	0
07/17/04	100	100	0	0	67	0	0	100	33	0	67	44	0	0	0	0	0	100	0	0	0	0
07/18/04	100	100	0	0	22	0	0	100	0	0	0	67	0	0	0	0	0	89	0	0	0	0
07/19/04	100	100	0	0	0	0	0	100	0	0	0	100	33	56	0	33	0	0	0	22	0	0
07/20/04	100	100	0	0	0	0	0	100	0	0	0	100	56	78	0	33	0	0	0	33	0	0
07/21/04	100	100	0	0	0	0	0	100	0	0	0	100	0	67	22	22	0	0	0	0	0	0
07/22/04	100	100	0	0	33	0	0	100	0	0	0	67	0	22	22	0	0	0	0	0	0	0
07/23/04	100	100	0	0	100	0	0	100	33	0	33	0	33	0	22	0	0	0	33	0	0	0
07/24/04	100	100	0	0	89	0	0	100	100	0	0	33	78	0	0	0	0	0	22	0	0	0
07/25/04	100	100	0	0	0	0	0	100	100	0	33	67	56	0	33	0	0	0	0	0	0	0
07/26/04	100	100	0	0	33	0	33	89	100	0	100	0	67	0	33	0	0	0	0	0	0	0
07/27/04	100	100	0	0	100	0	67	33	100	0	44	0	11	33	0	0	0	0	0	0	0	0
07/28/04	67	100	0	0	100	0	11	100	100	0	56	0	0	33	33	0	0	0	22	0	0	0
07/29/04	0	100	0	0	100	0	0	100	100	0	100	0	33	44	44	0	0	0	33	0	0	0

Appendix T. Percentages of time spill bay (S) 1 through 10 were operating during the day by date at The Dalles Dam, summer 2004. No spill discharge occurred at S11 through S23. Darker colors indicate higher percentage. Night refers to 2100 to 0529 hours.

Date	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
06/19/04	100	100	100	100	100	100	78	67	0	0
06/20/04	100	100	100	100	100	100	33	22	0	0
06/21/04	100	100	100	100	100	100	44	33	0	0
06/22/04	100	100	100	100	100	100	67	0	0	0
06/23/04	100	100	100	100	100	100	67	0	0	0
06/24/04	100	100	100	100	100	100	0	0	0	0
06/25/04	100	100	100	100	100	100	0	0	0	0
06/26/04	100	100	100	100	100	100	0	0	0	0
06/27/04	100	100	100	100	100	100	11	0	0	0
06/28/04	100	100	100	100	100	100	11	0	0	0
06/29/04	100	100	100	100	100	100	11	0	0	0
06/30/04	100	100	100	100	100	100	0	0	0	0
07/01/04	100	100	100	100	100	100	56	0	0	0
07/02/04	100	100	100	100	100	100	22	0	0	0
07/03/04	100	100	100	100	100	100	0	0	0	0
07/04/04	100	100	100	100	100	100	0	0	0	0
07/05/04	100	100	100	100	100	100	33	0	0	0
07/06/04	100	100	100	100	100	100	0	0	0	0
07/07/04	100	100	100	100	100	100	0	0	0	0
07/08/04	100	100	100	100	100	100	22	0	0	0
07/09/04	100	100	100	100	100	100	11	0	0	0
07/10/04	100	100	100	100	100	100	0	0	0	0
07/11/04	100	100	100	100	100	100	22	0	0	0
07/12/04	100	100	100	100	100	100	67	33	33	0
07/13/04	100	100	100	100	100	100	33	22	22	11
07/14/04	100	100	100	100	100	100	22	0	0	0
07/15/04	100	100	100	100	100	100	0	0	0	0
07/16/04	100	100	100	100	100	100	0	0	0	0
07/17/04	100	100	100	100	100	100	0	0	0	0
07/18/04	100	100	100	100	100	100	11	0	0	0
07/19/04	100	100	100	100	100	100	0	0	0	0
07/20/04	100	100	100	100	100	100	0	0	0	0
07/21/04	100	100	100	100	100	100	0	0	0	0
07/22/04	100	100	100	100	100	100	0	0	0	0
07/23/04	100	100	100	100	100	100	0	0	0	0
07/24/04	100	100	100	100	100	100	0	0	0	0
07/25/04	100	100	100	100	100	100	0	0	0	0
07/26/04	89	100	100	100	100	100	0	0	0	0
07/27/04	100	100	100	100	100	100	0	0	0	0
07/28/04	100	100	100	100	100	100	0	0	0	0
07/29/04	100	100	100	100	100	100	0	0	0	0

Appendix U. Results of logistic regressions to test for overall diel location effects at the upriver entrance on fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) and log-ratio comparisons of FPE, SPE, and SLPE between groups of subyearling Chinook salmon located at each of the upriver entrance areas above The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. The overall location effect was adjusted for 3 seasonal time periods (see Figures 39 through 41). NA = not applicable due to no overall location effect.). An asterisk (*) indicates significant effect or difference. *P*-values are based on the binomial-likelihood chi-square test (^{B}) or the quasi-likelihood F-test (^{Q}).

Passage efficiency	Test	Day *P*-value	Night *P*-value
FPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.1067^{Q}	0.1018^{Q}
SPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.1155^{Q}	0.0531^{Q}
SLPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.5621^{Q}	0.6504^{B}

Test for overdispersion HO: Variance component for time period = 0

	Day			Night		
	Deviance	df	*P*	Deviance	df	*P*
FPE	9.193	6	0.1630	9.960	6	0.1263
SPE	14.110	6	0.0284	9.949	6	0.1268
SLPE	36.723	6	<0.0001	4.782	6	0.5721

Residual analysis summary

Deviance residuals for the day and night analyses of FPE, SPE, and SLPE showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix V. Results of logistic regressions to test for overall day and night location effects at the downriver entrance on fish-, spill-, and sluiceway-passage efficiency (FPE, SPE, and SLPE) and log-ratio comparisons of FPE, SPE, and SLPE between groups of subyearling Chinook salmon located at each of the upriver entrance areas above The Dalles Dam, 19 June through 29 July 2004. NS = north shore. BN = barge north. BS = barge south. SS = south shore. The NS and BS locations were not included in the night analyses due to small sample sizes. The overall location effect was adjusted for 3 seasonal time periods (see figures 42 through 44). Asterisks (*) indicate significant effect or difference. *P*-values are based on the binomial-likelihood chi-square test (^{B}) or the quasi-likelihood F-test (^{Q}).

Passage efficiency	Test	Day *P*-value	Night *P*-value
FPE	HO: No location effect (adjusted for 3 seasonal time periods)	<0.0001^{B}*	<0.0001^{B}*
	NS vs. BN	0.0451*	-
	BN vs. BS	0.2097	-
	BN vs. SS	<0.0001*	<0.0001*
	BS vs. SS	0.0323*	-
SPE	HO: No location effect (adjusted for 3 seasonal time periods)	<0.0050^{Q}*	<0.0001^{Q}*
	NS vs. BN	0.7319	-
	BN vs. BS	0.0839	-
	BN vs. SS	0.0009*	<0.0001*
	BS vs. SS	0.0746	-
SLPE	HO: No location effect (adjusted for 3 seasonal time periods)	0.0464^{Q}*	0.3798 ^{Q}*
	NS vs. BN	0.3995	-
	BN vs. BS	0.1738	-
	BN vs. SS	0.0140*	NA
	BS vs. SS	0.4167	-

Test for overdispersion HO: Variance component for time period

	Day			Night		
	Deviance	df	*P*	Deviance	df	*P*
FPE	5.544	8	0.6982	3.699	4	0.4483
SPE	25.802	8	0.0011	8.951	4	0.0623
SLPE	28.548	8	0.0004	14.444	4	0.0060

Residual analysis summary

Deviance residuals for the day and night analyses of FPE, SPE, and SLPE showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix W. Estimates of subyearling Chinook salmon sluiceway passage efficiency (SLPE) two sluiceway operation treatments by date and logistic regression results comparing the treatments, 19 June through 17 July 2004. Treatments: MU18+MU01 = MU18 and MU01 entrances open, MU01 = MU01 entrances open. QRCI = quasi-likelihood confidence interval. *N* = sample size adjusted for detection efficiencies.

	Treatment						
	MU18 & MU01			MU01			Observed odds ratio
Block	SLPE	*N*	Odds	SLPE	*N*	Odds	
08	1.8	56	0.018	0.0	58	0.000	0.000
09	1.9	54	0.019	3.3	61	0.034	1.789
10	1.8	57	0.018	1.8	54	0.018	1.000
11	3.8	52	0.039	4.5	44	0.047	1.205
12	6.5	31	0.070	0.0	53	0.000	0.000
13	2.7	37	0.028	2.0	51	0.020	0.714
14	5.6	36	0.059	2.8	36	0.029	0.491
15	0.0	33	0.000	7.7	39	0.083	-
16	2.9	34	0.030	8.8	34	0.096	3.200
17	10.3	29	0.115	10.5	38	0.117	1.017
18	0.0	31	0.000	2.6	38	0.027	-
19	5.7	35	0.060	0.0	24	0.000	0.000
20	8.3	36	0.090	17.9	39	0.218	2.422
Overall odds ratio adjusted for date (95% QRCI)						1.221 (0.659 - 2.297)	
Test HO: odds ratio = 1 (no sluiceway treatment effect, F-test, *P* > 0.59)							

Test for overdispersion HO: Variance component for block = 0			
	Deviance	df	*P*
SLPE	41.681	24	0.0140

Residual analysis summary
Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix X. Estimates of subyearling Chinook salmon fish passage efficiency (FPE) during two sluiceway treatments and logistic regression results comparing diel periods, 19 June through 17 July 2004.   Treatments: MU18+MU01 = MU18 and MU01 entrances open, MU01 = MU01 entrances open. QRCI = quasi-likelihood confidence interval. *N* = sample size adjusted for detection efficiency.

	Treatment						
	MU18 & MU01			MU01			Observed
Block	FPE	N	Odds	FPE	N	Odds	odds ratio
08	87.5	56	7.000	86.2	58	6.246	0.892
09	77.8	54	3.505	77.0	61	3.348	0.955
10	87.7	57	7.130	68.5	54	2.175	0.305
11	78.8	52	3.717	88.6	44	7.772	2.091
12	96.8	31	30.250	84.9	53	5.623	0.186
13	86.5	37	6.407	80.4	51	4.102	0.640
14	88.9	36	8.009	97.2	36	34.714	4.334
15	78.8	33	3.717	84.6	39	5.494	1.478
16	97.1	34	33.483	85.3	34	5.803	0.173
17	79.3	29	3.831	92.1	38	11.658	3.043
18	87.1	31	6.752	86.8	38	6.576	0.974
19	85.7	35	5.993	91.7	24	11.048	1.844
20	97.2	36	34.714	94.9	39	18.608	0.536

Overall odds ratio adjusted for date (95% QRCI) 0.879 (0.621 – 1.240)

Test HO: odds ratio = 1 (no sluiceway treatment effect, F-test, *P* > 0.3783)

Test for overdispersion HO: Variance component for block = 0			
	Deviance	df	*P*
FPE	47.685	24	0.0028

Residual analysis summary
Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix Y. Diel daily estimates of subyearling Chinook salmon fish passage efficiency (FPE) during 40% spill discharge and logistic regression results comparing diel periods, 19 June through 29 July 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = quasi-likelihood confidence interval. *N* = sample sizes adjusted for detection efficiency.

	Day			Night			Observed odds
Date	FPE	*N*	Odds	FPE	*N*	Odds	ratio
19 Jun	100.000	6	-	90.000	10	9.000	<1.000
20 Jun	93.023	43	13.333	90.000	10	9.000	0.675
21 Jun	90.698	43	9.750	53.333	15	1.143	0.117
22 Jun	89.130	46	8.200	59.091	22	1.444	0.176
23 Jun	90.000	40	9.000	37.500	8	0.600	0.067
24 Jun	61.765	34	1.615	55.556	18	1.250	0.774
25 Jun	92.683	41	12.667	80.000	15	4.000	0.316
26 Jun	91.892	37	11.333	84.615	13	5.500	0.485
27 Jun	96.296	27	26.000	52.941	17	1.125	0.043
28 Jun	100.000	24	-	76.471	17	3.250	<1.000
29 Jun	87.500	40	7.000	100.000	8	-	>1.000
30 Jun	87.879	33	7.250	75.000	12	3.000	0.414
01 Jul	94.444	36	17.000	36.364	11	0.571	0.034
02 Jul	86.957	23	6.667	78.571	14	3.667	0.550
03 Jul	100.000	21	-	88.889	9	8.000	<1.000
04 Jul	96.296	27	26.000	85.714	14	6.000	0.231
05 Jul	100.000	22	-	61.538	13	1.600	<1.000
06 Jul	96.154	26	25.000	63.636	11	1.750	0.070
07 Jul	96.552	29	28.000	50.000	6	1.000	0.036
08 Jul	92.857	28	13.000	75.000	8	3.000	0.231
09 Jul	92.308	26	12.000	25.000	4	0.333	0.028
10 Jul	100.000	23	-	66.667	6	2.000	<1.000
11 Jul	96.296	27	26.000	41.667	12	0.714	0.027
12 Jul	100.000	20	-	84.615	13	5.500	<1.000
13 Jul	94.118	17	16.000	63.636	11	1.750	0.109
14 Jul	100.000	27	-	85.714	7	6.000	<1.000
15 Jul	97.059	34	33.000	71.429	7	2.500	0.076
16 Jul	92.308	26	12.000	75.000	12	3.000	0.250
17 Jul	100.000	39	-	92.308	13	12.000	<1.000
18 Jul	100.000	23	-	62.500	8	1.667	<1.000
19 Jul	97.727	44	43.000	59.091	22	1.444	0.034
20 Jul	96.552	29	28.000	60.000	10	1.500	0.054
21 Jul	94.872	39	18.500	55.556	18	1.250	0.068
22 Jul	89.189	37	8.250	60.000	20	1.500	0.182
23 Jul	92.500	40	12.333	40.000	15	0.667	0.054
24 Jul	100.000	17	-	66.667	21	2.000	<1.000
25 Jul	95.455	22	21.000	66.667	15	2.000	0.095
26 Jul	89.831	59	8.833	56.250	32	1.286	0.146
27 Jul	95.745	47	22.500	47.826	23	0.917	0.041
28 Jul	88.636	44	7.800	57.692	26	1.364	0.175
29 Jul	91.892	37	11.333	58.333	12	1.400	0.124

Overall odds ratio adjusted for date (95% QRCI) 0.121 (0.084 - 0.171)

Test HO: odds ratio = 1 (no diel effect, F-test, $P < 0.0001$)

Test for overdispersion HO: Variance component for date = 0, Deviance = 137.084 , df = 80 , $P < 0.0001$.

Residual analysis summary: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix Z. Diel daily estimates of subyearling Chinook salmon spill passage efficiency (SPE) during 40% bulk spill discharge and logistic regression results comparing diel periods, 19 June through 29 July 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = quasi-likelihood confidence interval. *N* = sample sizes adjusted for detection efficiency.

	Day			Night			Observed odds
Date	SPE	N	Odds	SPE	N	Odds	ratio
19 Jun	83.3	6	5.000	90.0	10	9.000	1.800
20 Jun	93.0	43	13.333	90.0	10	9.000	0.675
21 Jun	88.4	43	7.600	53.3	15	1.143	0.150
22 Jun	87.0	46	6.667	54.5	22	1.200	0.180
23 Jun	87.5	40	7.000	37.5	8	0.600	0.086
24 Jun	58.8	34	1.429	55.6	18	1.250	0.875
25 Jun	92.7	41	12.667	80.0	15	4.000	0.316
26 Jun	86.5	37	6.400	84.6	13	5.500	0.859
27 Jun	88.9	27	8.000	47.1	17	0.889	0.111
28 Jun	100.0	24	-	70.6	17	2.400	<1.000
29 Jun	87.5	40	7.000	87.5	8	7.000	1.000
30 Jun	87.9	33	7.250	66.7	12	2.000	0.276
01 Jul	94.4	36	17.000	36.4	11	0.571	0.034
02 Jul	82.6	23	4.750	64.3	14	1.800	0.379
03 Jul	100.0	21	-	88.9	9	8.000	<1.000
04 Jul	92.6	27	12.500	71.4	14	2.500	0.200
05 Jul	100.0	22	-	53.8	13	1.167	<1.000
06 Jul	96.2	26	25.000	63.6	11	1.750	0.070
07 Jul	89.7	29	8.667	16.7	6	0.200	0.023
08 Jul	85.7	28	6.000	62.5	8	1.667	0.278
09 Jul	80.8	26	4.200	0.0	4	0.000	0.000
10 Jul	100.0	23	-	66.7	6	2.000	<1.000
11 Jul	96.3	27	26.000	33.3	12	0.500	0.019
12 Jul	90.0	20	9.000	84.6	13	5.500	0.611
13 Jul	94.1	17	16.000	63.6	11	1.750	0.109
14 Jul	96.3	27	26.000	71.4	7	2.500	0.096
15 Jul	85.3	34	5.800	28.6	7	0.400	0.069
16 Jul	88.5	26	7.667	66.7	12	2.000	0.261
17 Jul	89.7	39	8.750	84.6	13	5.500	0.629
18 Jul	78.3	23	3.600	50.0	8	1.000	0.278
19 Jul	75.0	44	3.000	45.5	22	0.833	0.278
20 Jul	82.8	29	4.800	60.0	10	1.500	0.313
21 Jul	79.5	39	3.875	55.6	18	1.250	0.323
22 Jul	83.8	37	5.167	55.0	20	1.222	0.237
23 Jul	80.0	40	4.000	26.7	15	0.364	0.091
24 Jul	100.0	17	-	61.9	21	1.625	<1.000
25 Jul	90.9	22	10.000	53.3	15	1.143	0.114
26 Jul	69.5	59	2.278	50.0	32	1.000	0.439
27 Jul	83.0	47	4.875	43.5	23	0.769	0.158
28 Jul	84.1	44	5.286	50.0	26	1.000	0.189
29 Jul	78.4	37	3.625	58.3	12	1.400	0.386
Overall odds ratio adjusted for date (95% QRCI)							0.198 (0.145 - 0.269)

Test HO: odds ratio = 1 (no diel effect, F-test, $P < 0.0001$)

Test for overdispersion HO: Variance component for date = 0, Deviance = 159.683 , df = 80 , $P < 0.0001$.
Residual analysis summary: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.

Appendix AA. Diel daily estimates of subyearling Chinook salmon sluice passage efficiency (SLPE) during 40% bulk spill discharge and logistic regression results comparing 19 June through 29 July 2004. Day equals 0530 to 2059 hours and night equals 2100 to 0529 hours. QRCI = profile-likelihood confidence interval. *N* = sample sizes have been adjusted for detection efficiencies.

	Day			Night			Observed odds
Date	SLPE	*N*	Odds	SLPE	*N*	Odds	ratio
19&20 Jun	2.000	49	0.020	0.0	20	0.000	0.000
21 Jun	2.326	43	0.024	0.0	14	0.000	0.000
22 Jun	2.174	46	0.022	4.8	21	0.050	2.241
23 Jun	2.500	40	0.026	0.0	8	0.000	0.000
24 Jun	2.941	34	0.030	0.0	17	0.000	0.000
25&26 Jun	2.564	78	0.013	0.0	28	0.000	0.000
27 Jun	7.407	27	0.080	6.2	16	0.066	0.827
28 Jun	0.000	24	0.000	5.9	17	0.063	>1.000
29 Jun	0.000	40	0.000	12.5	8	0.143	>1.000
30 Jun	0.000	33	0.000	8.3	12	0.091	>1.000
01&02 Jul	1.695	59	0.019	8.3	24	0.091	4.789
03&04 Jul	2.083	48	0.021	8.7	23	0.095	4.538
05&06 Jul	0.000	48	0.000	4.1	24	0.043	>1.000
07 Jul	6.897	29	0.074	33.3	6	0.499	6.736
08 Jul	7.143	28	0.076	12.5	8	0.143	1.869
09&10 Jul	6.122	49	0.065	10.0	10	0.111	1.708
11 Jul	0.000	27	0.000	9.0	11	0.099	0.000
12 Jul	10.000	20	0.111	0.0	13	0.000	0.000
13&14 Jul	2.273	44	0.023	5.6	18	0.059	2.579
15 Jul	11.765	34	0.134	42.9	7	0.751	5.616
16 Jul	3.846	26	0.040	8.3	12	0.091	2.291
17 Jul	10.256	39	0.115	7.7	13	0.083	0.727
18 Jul	21.739	23	0.277	12.5	8	0.143	0.515
19 Jul	22.727	44	0.294	14.3	21	0.167	0.568
20 Jul	13.793	29	0.160	0.0	10	0.000	0.000
21 Jul	15.385	39	0.182	0.0	17	0.000	0.000
22 Jul	5.405	37	0.057	5.3	19	0.056	0.980
23 Jul	12.500	40	0.143	14.3	14	0.167	1.168
24 Jul	0.000	17	0.000	5.0	20	0.053	>1.000
25 Jul	4.545	22	0.047	13.3	15	0.153	3.256
26 Jul	20.339	59	0.255	6.5	31	0.070	0.273
27 Jul	12.766	47	0.147	4.5	22	0.047	0.321
28 Jul	4.545	44	0.047	8.0	25	0.087	1.845
29 Jul	13.514	36	0.161	0.0	11	0.000	0.000

Overall odds ratio adjusted for date (95% QRCI) 0.970 (0.578 - 1.584)

Test HO: odds ratio = 1 (no diel effect, F-test, $P < 0.9048$)

Test for overdispersion HO: Variance component for date = 0, Deviance = 124.573, df = 66, $P < 0.0001$.

Residual analysis summary: Deviance residuals showed no problems such as obvious outliers, heterogeneity of variation, or strong skew.